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UNITED STATES
DEPARTMENT OF THE INTERIOR
J. A. KRUG, SECRETARY

BUREAU OF MINES
R. R. SAYERS, DIRECTOR

REPORT OF INVESTIGATIONS

INVESTIGATION OF COAL DEPOSITS IN THE COAL CREEK DISTRICT
GUNNISON COUNTY, COLO.

PROGRESS REPORT 1



BY

ALBERT L. TOENGENS, LOUIS A. TURNBULL,
J. D. DAVIS, AND D. A. REYNOLDS

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INTRODUCTION

Additional sources of coking coal west of the Continental Divide are needed for western steel plants, and as the analyses of coal obtained in diamond-drill cores in a hole drilled in Gunnison County, Colo., at the confluence of Anthracite Creek and the North Fork of Gunnison River indicated that these coals had coking qualities, a reconnaissance was made of the area adjacent to Anthracite, Muddy, Snowshoe, and Coal Creeks. This area is being investigated by diamond drilling.

The interest shown by coal-mine operators in the west in additional reserves of coking coal has made it advisable to publish the preliminary results of the investigation in this Progress Report. Investigations in the area will be continued, and upon completion of this work a technical paper will be published giving the final results, which may revise the conclusions contained in this Progress Report.

The field investigation was under the direction of Albert L. Toenges, Louis A. Turnbull, and Raymond G. Travis, mining engineer. Geological work was done by Vard H. Johnson of the Federal Geological Survey. Carbonizing tests were directed by J. D. Davis, assisted by D. A. Reynolds, and the results of these tests are discussed. Coal analyses were supervised by H. M. Cooper, senior chemist, and miscellaneous analyses were under the direction of W. A. Selvig, senior chemist.

DESCRIPTION OF THE AREA

The area investigated comprises secs. 4, 7, 8, 9, 10, 11, 15, 16, 21, 22, 23, and 28, T. 13 S., R. 89 W., Gunnison County, Colo. The coal and mining rights in most of the land in the area are owned by the government. The center of the area is approximately 6 miles east of the end of the Denver & Rio Grande Western standard-gage line to Somerset and the Oliver mine.

TOPOGRAPHY AND GEOLOGY

The topography of the area is mountainous and is traversed by several streams, which unite to form the North Fork of the Gunnison River. Altitudes range from 6,200 feet in the valleys to 8,000 feet on the plateaus. Marcelina and West Beckwith Mountains, which are east of the area, rise to altitudes over 12,000 feet.

The geology of the district is described by Lee.^{6/} Briefly, the coal beds occur in the Mesaverde formation of upper Cretaceous age. The coal-bearing members comprise sandstone, shale, and coal beds. The coals, which are bituminous in rank, occur in the strata above the Rollins sandstone. The prevailing dip is approximately 5 percent, or 3 degrees northeast.

^{6/} Lee, W. T., Coal Fields of Grand Mesa and West Elk Mountain, Colorado: U. S. Geol. Survey Bull. 510, 1912, pp. 112-139.

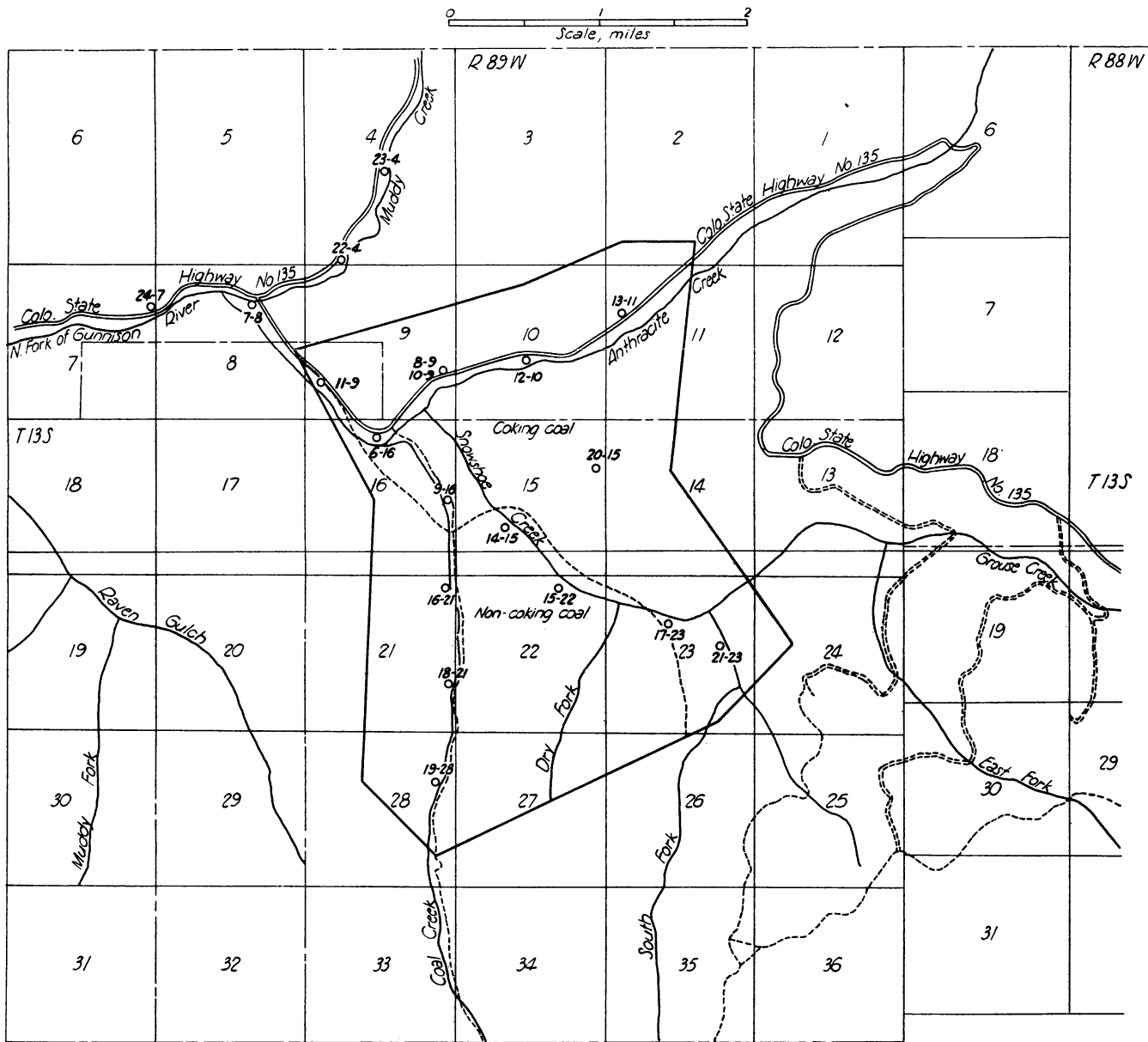


Figure 1 - Diamond drilling in Coal Creek area, Gunnison County, Colorado.

DIAMOND DRILLING

Diamond drilling was done for the Bureau of Mines under contract by the Pennsylvania Drilling Co. To date, 18 diamond-drill holes to obtain minimum 2-1/8-inch cores have been drilled to determine the thickness, physical characteristics, and extent of the coal beds and the character of the overlying and underlying strata. One hole to recover 8-inch cores of the coal beds was drilled to obtain enough coal for carbonization tests.

The locations of the holes are shown in figure 1, and condensed logs of the holes and chemical analyses of the coal cores are given in the Appendix.

INTERPRETATION OF DRILLING RESULTS

The results obtained in diamond drilling show that the minable coal beds exist near the base of the coal-bearing formations immediately above the Rollins sandstone. Three coal beds were found to be reasonably persistent at this horizon. The Upper bed, in sections 9, 10, 11, and the north half of sections 15 and 16, ranges from 3 feet 9 inches to 5 feet 3 inches in thickness. In other parts of the area, this bed apparently is not minable. The Middle bed is fairly persistent at minable thickness throughout the area. It ranges in thickness from 4 feet to 10 feet 3 inches, except in hole 9-16, where it is only 1 foot 10 inches thick. However, drilling indicated that this bed is part of the Lower bed in some places, as shown in the logs of holes 14-15, 15-22, 17-23, and 21-23. The Lower bed is the most persistent in thickness and extent throughout the area. The thickness of this bed ranges from 6 feet 4 inches to 14 feet 10 inches, except in holes 16-21, 18-21, and 19-28, where the bed is very thin. These three holes are on Coal Creek, at the southern end of the area drilled, and it is evident that the Lower bed is not present at minable thickness in this particular area.

The additional work to be done in the Coal Creek District will furnish more data regarding the thickness and continuity of these three beds.

Preliminary estimates of measured reserves of coal in the area tested by drilling to date, are as follows:

	Tons
Coking coal.....	65,000,000
Noncoking coal.....	35,000,000
	<u>100,000,000</u>

The recovery in mining should range from 70 to 80 percent of the total reserves.

The first hole drilled at this project (6-16) encountered a small amount of oil and a strong flow of gas at a depth of 400 feet, about 250 feet above the upper minable coal bed. Samples of the oil were analyzed

at the Bureau of Mines Petroleum and Oil-Shale Experiment Station, Laramie, Wyo. The results of those analyses show the oil to be a low-gravity, naphthenic oil, which contains no gasoline or kerosene and has no lubricating qualities. Evidently, the oil has little commercial value except as cracking stock in a refinery.

Gas was found in most of the holes, and the quantities and pressures were especially large in hole 19-28 and other holes on Coal Creek. The gas apparently is present in several hundred feet of strata above the coal beds as well as at the horizon of the coals and must be considered in planning mining operations.

A strong flow of water also was found in hole 19-28 at about the horizon of the coal beds. No doubt, the intensity of this flow was increased by the pressure of the gas in the hole. Water was found in other holes, but not in amounts that would affect mining operations adversely.

YIELDS OF CARBONIZATION PRODUCTS AND PROPERTIES OF COKE

The cores from hole 10-9 were large enough to be carbonized by the Bureau of Mines-American Gas Association (BM-AGA) method, using 13-inch-diameter cylindrical retorts of about 85 pounds capacity. Table 1 gives the yields of carbonization products at 900° C., and table 2 gives the physical properties of the cokes. Corresponding results for Sunnyside coal, Sunnyside mine, Carbon County, Utah, are included in both tables for comparison.

The drilled samples yielded more coke, gas, and tar and less liquor than the Sunnyside coal, although the differences were small. The Lower bed (286) gave the highest yield of coke, 65.2 percent; the Middle bed (285) yielded the most gas, 18.1 percent; and the Upper bed (284) gave the highest yield of tar, 7.5 percent. Differences in the yields of liquor, ammonium sulfate, and light oil probably are not significant.

The quality of the cokes obtained from the drilled samples may be judged by comparing their strength-test indexes with those of the coke obtained from Sunnyside coal under identical test conditions. The coking properties of Sunnyside coal are well-known, and the sample used in this study was representative of the bed. These data indicate that the Upper and Lower beds coke more strongly than the Sunnyside bed. The Middle bed yielded weaker coke than the Upper and Lower beds; it was slightly inferior to Sunnyside coke. Technologists of the Columbia Steel Co. judge their coke largely by the proportion that remains on the 1/2-inch screen in the tumbler test, which, in their opinion, should be 80 percent or more. By that standard the cokes from the Upper and Lower beds would qualify as metallurgical grade.

The chemical composition of the cokes from all three beds was satisfactory. The cokes from the Upper, Middle, and Lower beds contained 6.3, 8.3, and 10.9 percent ash, and 0.9, 0.5, and 0.4 percent sulfur, respectively.

TABLE 1. - Yields of carbonization products, as-carbonized basis

Coal No.	Description	Yields, percent by weight of coal							Yields per ton of coal			
		Coke	Gas	Tar	Light oil	Free ammonia	Liquor	Total	Gas, cubic feet	Tar, gal- lons	Light oil, gallons in gas	(NH ₄) ₂ SO ₄ , pounds
284	Upper core.	64.2	17.4	7.5	0.85	0.124	7.7	97.8	10,800	15.7	2.35	21.7
285	Middle core	64.5	18.1	6.7	.95	.128	7.0	97.4	11,100	13.8	2.62	20.4
286	Lower core.	65.2	17.3	7.2	.87	.120	7.3	98.0	10,500	15.0	2.43	20.9
276	Sunnyside..	64.1	17.0	6.4	.93	.101	8.6	97.1	10,550	13.2	2.54	16.4

TABLE 2. - Physical properties of coke, determined by Columbia Steel Co. methods

Coal No.	Description	Shatter test, cumulative percent upon -				Tumbler test, Cumulative percent, upon -			
		1-1/2-inch	1-inch	3/4-inch	1/2-inch	1-1/2-inch	1-inch	3/4-inch	1/2-inch
		screen	screen	screen	screen	screen	screen	screen	screen
284	Upper core.	51	81	88	94	22	62	71	80
285	Middle core	28	70	80	91	19	53	64	76
286	Lower core.	37	80	89	96	25	65	76	84
276	Sunnyside..	43	75	84	92	20	55	65	76

CONCLUSIONS

The investigation of coal deposits to date in the Coal Creek District, Gunnison County, Colo., show that three minable coal beds underlie the area. The beds, which occur in the Mesaverde formation, Cretaceous age, vary somewhat in thickness in parts of the area. The Lower bed appears to be the most regular in thickness and extent. A preliminary estimate of measured reserves in the area tested by drilling shows approximately 65,000,000 tons of coking coal and 35,000,000 tons of noncoking coal, a total of 100,000,000 tons of coal, of which 70 to 80 percent is considered recoverable.

The quality of the cokes obtained from the drilled samples may be judged by comparing their strength-test indexes with those of the coke obtained from Sunnyside coal under identical test conditions. These data indicate that the Upper and Lower beds coke more strongly than the Sunnyside bed. The Middle bed yielded weaker coke than the Upper and Lower beds; it was slightly inferior to Sunnyside coke. By Columbia Steel Co. standards, the cokes from these coals would qualify as metallurgical grade.

Large quantities of gas under high pressure were found in many of the diamond-drill holes, and the reduction of gas pressure and quantities must be given consideration in the development of mines in this field.

Additional diamond drilling will be done and carbonization tests made on coal in another part of the area. Final estimates of reserves and conclusions as to the coking quality of the coals cannot be made until the investigation is completed.

APPENDIX

Condensed logs of diamond-drill holesHole 6-16

Location: 600 feet S. and 100 feet W. of N. 1/4 corner, sec. 16, T. 13 S.,
R. 89 W.

Surface elevation: 6,358 feet.

Depth				Material	Thickness		Remarks
From-		To-			Ft.	In.	
Ft.	In.	Ft.	In.				
0	0	605	0	Shale, sandstone, and thin coal beds.....	605	0	
605	0	658	3	Sandstone.....	53	3	
658	3	662	6	COAL.....	4	3	
662	6	663	0	Carbonaceous shale.....	0	6	
663	0	667	6	Mottled, sandy shale.....	4	6	
667	6	675	3	Dark and carbonaceous shale..	7	9	
675	3	680	11	COAL.....	5	8	
680	11	681	8	Carbonaceous shale.....	0	9	
681	8	686	10	Shaly sandstone.....	5	2	
686	10	688	4	COAL.....	1	6	
688	4	694	10	Sandy shale.....	6	6	
694	10	695	4	Carbonaceous shale.....	0	6	
695	4	702	3	COAL.....	6	11	
702	3	702	11	Carbonaceous sandstone.....	0	8	Top of Rollins
702	11	744	0	Rollins sandstone.....	41	0	sandstone 702 ft., 11 in.

Hole 7-8

Location: 1,300 feet S. and 1,800 feet W. of N. E. corner, sec. 8, T. 13
S., R. 89 W.

Surface elevation: 6,276 feet.

Depth				Material	Thickness		Remarks
From-		To-			Ft.	In.	
Ft.	In.	Ft.	In.				
0	0	541	0	Shale, sandstone, and thin coal beds.....	541	0	
541	0	579	2	Medium sandstone.....	38	2	
579	2	579	7	Brown to black carbonaceous shale.....	0	5	
579	7	580	2	Bone coal.....	0	7	
580	2	583	11	COAL.....	3	9	
583	11	585	2	Black, carbonaceous shale, coal streaks.....	1	3	
585	2	585	5	Bone coal.....	0	3	
585	5	595	10	Black carbonaceous shale, coal streaks, and plant casts	10	5	

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Hole 8-9

Location: 1,500 feet N. and 600 feet W. of S. E. corner, sec. 9, T. 13 S.,
R. 89 W.

Surface elevation: 6,447 feet.

Depth				Material	Thickness		Remarks
From-		To-			Ft.	In.	
Ft.	In.	Ft.	In.				
0	0	908	0	Shale, sandstone, and thin coal beds.....	908	0	
908	0	929	3	Medium sandstone containing carbonaceous material.....	21	3	
929	3	933	9	COAL.....	4	6	
933	9	934	8-1/2	Carbonaceous shale.....	0	11-1/2	
934	8-1/2	934	9-1/2	Bony coal.....	0	1	
934	9-1/2	942	6	Carbonaceous, sandy shale....	7	8-1/2	
942	6	943	0	Bone.....	0	6	
943	0	950	0	COAL.....	7	0	
950	0	952	7-1/4	Mottled, gray, silty shale and carbonaceous shale.....	2	7-1/4	
952	7-1/4	953	8-3/4	Carbonaceous shale.....	1	1-1/2	
953	8-3/4	954	2-1/4	COAL.....	0	5-1/2	
954	2-1/4	955	11-1/4	Carbonaceous shale.....	1	9	
955	11-1/4	962	6	COAL.....	6	6-3/4	
962	6	963	2	Sandy bone.....	0	8	Top of Rollins sandstone 963 ft.
963	2	972	9	Medium to coarse sandstone with plant casts and scattered streaks of carbonaceous material.....	9	7	
972	9	1003	0	Medium sandstone with abundant halymenites.....	30	3	

Hole 9-16

Location: 2,700 feet N. and 250 feet W. of S. E. corner, sec. 16, T. 13 S.,
R. 89 W.

Surface elevation: 6,400 feet.

Depth				Material	Thickness		Remarks
From-		To-			Ft.	In.	
Ft.	In.	Ft.	In.				
0	0	701	6	Shale, sandstone, and thin coal beds.....	701	6	
701	6	706	0	Sandstone.....	4	6	
706	0	710	0	Dark shale.....	4	0	
710	0	711	6	Carbonaceous shale.....	1	6	
711	6	713	5	Gray shale.....	1	11	
713	5	713	8	Carbonaceous shale.....	0	3	

Hole 9-16 (Cont'd.)

Depth				Material	Thickness		Remarks
From-		To-			Ft.	In.	
Ft.	In.	Ft.	In.				
713	8	718	11	COAL.....	5	3	
718	11	719	11	Carbonaceous shale.....	1	0	
719	11	720	9	Gray shale.....	0	10	
720	9	720	10-1/2	Bone.....	0	1-1/2	
720	10-1/2	722	9	COAL.....	1	10-1/2	
722	9	723	9	Carbonaceous shale.....	1	0	
723	9	725	0	Dark shale.....	1	3	
725	0	729	8	Fine, silty sandstone with streaks of coal and shale breccia.....	4	8	
729	8	730	0	Sandy bone.....	0	4	
730	0	736	8	COAL.....	6	8	
736	8	737	1	Sandy bone.....	0	5	Top of Rollins
737	1	738	0	Carbonaceous sandstone.....	0	11	sandstone, 737
738	0	762	0	Sandstone with coal flecks...	24	0	ft.

Hole 10-9

Location: 1,500 feet N. and 560 feet W. of S. E. corner, sec. 9, T. 13 S.,
R. 89 W.

Surface elevation: 6,450 feet.

Depth				Material	Thickness		Remarks
From-		To-			Ft.	In.	
Ft.	In.	Ft.	In.				
0	0	910	0	Shale, sandstone, and thin coal beds.....	910	0	
910	0	932	8-1/2	Medium sandstone with carbonaceous material.....	22	8-1/2	
932	8-1/2	936	9-1/2	COAL.....	4	1	
936	9-1/2	942	7	Carbonaceous shale.....	5	9-1/2	
942	7	945	8	Dark shale with plant remains and coal streaks.....	3	1	
945	8	946	1	Bone.....	0	5	
946	1	952	7	COAL.....	6	6	
952	7	952	10	Carbonaceous shale with coal streaks.....	0	3	
952	10	954	3	Grayish-black carbonaceous shale.....	1	5	
954	3	955	9	Black, carbonaceous shale with coal streaks.....	1	6	
955	9	956	2	COAL.....	0	5	
956	2	958	0	Carbonaceous shale.....	1	10	
958	0	958	2	Bone.....	0	2	
958	2	964	11	COAL.....	6	9	
964	11	965	1	Sandy bone.....	0	2	Top of Rollins
965	1	966	3	Medium to coarse sandstone with plant casts and scattered streaks of carbonaceous material.....	1	2	sandstone, 965 ft., 1 in.

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Hole 11-9

Location: 1,400 feet N. and 500 feet, E. of S. W. corner, sec. 9, T. 13 S.,
R. 89 W.

Surface elevation: 6,385 feet.

Depth				Material	Thickness		Remarks
From-		To-			Ft.	In.	
Ft.	In.	Ft.	In.				
0	0	714	0	Shale, sandstone, and thin coal beds.....	714	0	
714	0	727	10	Coarse sandstone.....	13	10	
727	10	728	8	Carbonaceous shale.....	0	10	
728	8	735	0	COAL.....	6	4	Top of Rollins sandstone, 736 ft., 2 in.
735	0	736	2	Carbonaceous sandstone.....	1	2	
736	2	747	0	Medium sandstone with streaks of shale and coal.....	10	10	
747	0	748	0	Shale.....	1	0	
748	0	765	0	Medium sandstone.....	17	0	

Hole 12-10

Location: 2,200 feet N. and 2,600 feet E. of S. W. corner, sec. 10, T. 13 S., R. 89 W.

Surface elevation: 6,492 feet.

Depth				Material	Thickness		Remarks
From-		To-			Ft.	In.	
Ft.	In.	Ft.	In.				
0	0	1083	0	Shale, sandstone, and thin coal beds.....	1083	0	
1083	0	1095	0	Interbedded sandstone and shale with halymenites.....	12	0	
1095	0	1099	0	Medium sandstone.....	4	0	
1099	0	1102	9	COAL.....	3	9	
1102	9	1109	0	Carbonaceous shale.....	6	3	
1109	0	1116	0	Gray shale and sandy shale...	7	0	
1116	0	1131	6	Medium to coarse sandstone (cross-bedded).....	15	6	
1131	6	1137	2	COAL.....	5	8	
1137	2	1140	11	Gray shale.....	3	9	
1140	11	1141	4	Black carbonaceous shale.....	0	5	
1141	4	1142	0	COAL.....	0	8	
1142	0	1142	3	Bone.....	0	3	
1142	3	1142	10	Carbonaceous shale.....	0	7	
1142	10	1143	0	COAL.....	0	2	
1143	0	1145	4	Sandy, carbonaceous shale....	2	4	
1145	4	1151	8	COAL.....	6	4	
1151	8	1151	11	Sandy bone.....	0	3	
1151	11	1152	3	Carbonaceous sandstone.....	0	4	Top of Rollins sandstone, 1152 ft.
1152	3	1185	0	Medium sandstone.....	32	9	

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Hole 13-11

Location: 1,700 feet S. and 600 feet E. of N. W. corner, sec. 11, T. 13 S.,
R. 89 W.

Surface elevation: 6,530 feet.

Depth				Material	Thickness		Remarks
From-		To-			Ft.	In.	
Ft.	In.	Ft.	In.				
0	0	1290	0	Shales, sandstones, and thin coal beds.....	1290	0	
1290	0	1301	10	Medium massive sandstone.....	11	10	
1301	10	1305	10	COAL.....	4	0	
1305	10	1306	7	Bone.....	0	9	
1306	7	1308	7	Carbonaceous shale.....	1	0	
1308	7	1311	11	Slightly carbonaceous, dark shale.....	3	4	
1311	11	1312	3	Bone.....	0	4	
1312	3	1317	10	Coal with vertical jointing..	5	7	
1317	10	1318	8	Carbonaceous shale.....	0	10	
1318	8	1322	0	Gray shale, slightly sandy, with slickensides from 1,321 to 1,322 ft.	3	4	
1322	0	1326	6	Sandstone with veinlets of calcite at 1,323 ft. 4 in. and 1,325 ft.	4	6	
1326	6	1326	8	Bone with streaks of coal....	0	2	
1326	8	1327	4	Dark, carbonaceous shale.....	0	8	
1327	4	1334	11	COAL.....	7	7	
1334	11	1335	5	Carbonaceous sandstone.....	0	6	Top of Rollins sandstone, 1,335 ft.
1335	5	1340	0	Medium sandstone.....	4	7	

Hole 14-15

Location: 3,850 feet S. and 1,620 feet E. of N. W. corner, sec. 15, T. 13
S., R. 89 W.

Surface elevation: 6,534 feet.

Depth				Material	Thickness		Remarks
From-		To-			Ft.	In.	
Ft.	In.	Ft.	In.				
0	0	839	0	Shale, sandstone, and thin coal beds.....	839	0	
839	0	841	0	Dark, shaly sandstone.....	2	0	
841	0	852	0	Dark shale.....	11	0	
852	0	856	0	Mottled, shaly sandstone.....	4	0	
856	0	858	6	Fine sandstone.....	2	6	
858	6	864	6	Interbedded shale and sandstone.....	6	0	
864	6	866	0	Dark shale.....	1	6	
866	0	872	9-1/2	Coal with vertical jointing..	6	9-1/2	
872	9-1/2	872	11	Bone.....	0	1-1/2	
872	11	879	10	COAL.....	6	11	
879	10	880	6	Sandy bone.....	0	8	
880	6	881	0	Carbonaceous sandstone.....	0	6	Top of Rollins sandstone, 881 ft.
881	0	888	0	Medium sandstone with flecks of coal.....	7	0	

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Hole 15-22

Location: 400 feet S. and 1,480 feet W. of N. E. corner, sec. 22, T. 13 S.,
R. 89 W.

Surface elevation: 6,650 feet.

Depth				Material	Thickness		Remarks
From-		To-			Ft.	In.	
Ft.	In.	Ft.	In.				
0	0	906	6	Shale, sandstone, and thin coal beds.....	906	6	
906	6	919	0	Fine sandstone with scattered halymenites.....	12	6	
919	0	925	0	Interbedded sandstone and shale, carbonaceous, on top of coal.....	6	0	
925	0	927	10	COAL.....	2	10	
927	10	934	0	Interbedded sandstone and shale.....	6	2	
934	0	940	0	Gray shale and dark shale....	6	0	
940	0	945	0	Fine sandstone.....	5	0	
945	0	961	6	Medium to coarse sandstone with scattered streaks of carbonaceous material.....	16	6	
961	6	963	6	Banded sandstone with shaly partings.....	2	0	
963	6	973	10	Sandstone with shale breccia.	10	4	
973	10	975	4	Dark shale.....	1	6	
975	4	976	2	Bone.....	0	10	
976	2	990	7	COAL.....	14	5	
990	7	991	4	Sandy bone.....	0	9	Top of Rollins sandstone, 991 ft.
991	4	991	7	Carbonaceous sandstone.....	0	3	
991	7	1018	0	Medium sandstone.....	26	5	

Hole 16-21

Location: 500 feet S. and 300 feet W. of the N. E. corner, sec. 21, T. 13 S., R. 89 W.

Surface elevation: 6,440 feet.

Depth				Material	Thickness		Remarks
From-		To-			Ft.	In.	
Ft.	In.	Ft.	In.				
0	0	544	0	Shale, sandstone, and thin coal beds.....	544	0	
544	0	589	0	Fine to medium sandstone with flecks of carbonaceous material in lower part.....	45	0	
589	0	589	3	Carbonaceous sandstone.....	0	3	
589	3	592	6	COAL.....	3	3	
592	6	594	6	Dark, carbonaceous shale (sheared and with slickensides).....	2	0	

Hole 16-21 (Cont'd.)

Depth				Material	Thickness		Remarks
From-		To-			Ft.	In.	
Ft.	In.	Ft.	In.				
594	6	605	6	Medium sandstone.....	11	0	
605	6	614	6	Gray shale.....	9	0	
614	6	622	2	Mottled, shaly sandstone (lower 6 in. a carbonaceous sandstone).....	7	8	
622	2	628	5	COAL.....	6	3	
628	5	628	9	Bone.....	0	4	
628	9	631	9	COAL.....	3	0	
631	9	632	1	Bone.....	0	4	
632	1	632	6	Carbonaceous shale.....	0	5	
632	6	633	9	Gray shale.....	1	3	
633	9	634	2	Carbonaceous shale.....	0	5	
634	2	636	11	COAL.....	2	9	
636	11	637	3	Carbonaceous sandstone.....	0	4	Top of Rollins sandstone, 637 ft.
637	3	647	2	Medium sandstone.....	9	11	

Hole 17-23

Location: 1,700 feet S. and 1,500 feet E. of N. W. corner, sec. 23, T. 13
S., R. 89.W.
Surface elevation: 6,740 feet.

Depth				Material	Thickness		Remarks
From-		To-			Ft.	In.	
Ft.	In.	Ft.	In.				
0	0	1092	6	Shale, sandstone, and thin coal beds.....	1092	6	
1092	6	1116	0	Fine sandstone with laminae of carbonaceous material....	23	6	
1116	0	1125	0	Interbedded sandy shale and shaly sandstone.....	9	0	
1125	0	1127	6	Shaly sandstone with a pattern of vertical streaks resem- bling halycites corals. Streaks probably represent grass roots.....	2	6	
1127	6	1127	11	Bone.....	0	5	
1127	11	1142	9	COAL.....	14	10	
1142	9	1143	1	Sandy bone.....	0	4	
1143	1	1143	9	Carbonaceous sandstone.....	0	8	
1143	9	1150	0	Medium sandstone.....	6	3	Top of Rollins sandstone, 1,144 ft.

Hole 18-21

Location: 3,700 feet S. and 200 feet W. of N. E. corner, sec. 21, T. 13 S., R. 89 W.

Surface elevation: 6,500 feet.

Depth				Material	Thickness		Remarks
From-		To-			Ft.	In.	
Ft.	In.	Ft.	In.				
0	0	463	0	Shale, sandstone, and thin coal beds.....	463	0	
463	0	504	0	Fine to medium sandstone.....	41	0	
504	0	507	0	COAL.....	3	0	
507	0	507	5	Carbonaceous shale.....	0	5	
507	5	513	6	Gray shale with streaks of carbonaceous material and plant remains.....	6	1	
513	6	518	0	Shaly sandstone.....	4	6	
518	0	522	0	Gray shale.....	4	0	
522	0	533	0	Shaly sandstone.....	11	0	
533	0	536	6	Gray shale with plant remains	3	6	
536	6	537	0	Bone.....	0	6	
537	0	546	8	COAL.....	9	8	
546	8	547	2	Carbonaceous shale.....	0	6	
547	2	558	2	Medium massive sandstone.....	11	0	
558	2	561	0	Gray shale and sandy shale...	2	10	
561	0	563	0	Sandstone with shale breccia.	2	0	
563	0	568	0	Gray shale.....	5	0	
568	0	568	6	Carbonaceous shale.....	0	6	
568	6	569	7	COAL (bony coal).....	1	1	
569	7	570	1	Sandy bone.....	0	6	
570	1	571	0	Carbonaceous sandstone.....	0	11	Top of Rollins sandstone, 571 ft.
571	0	576	0	Medium sandstone.....	5	0	

Hole 19-28

Location: 1,800 feet S. and 750 feet W. of N. E. corner, sec. 28, T. 13 S., R. 89 W.

Surface elevation: 6,560 feet.

Depth				Material	Thickness		Remarks
From-		To-			Ft.	In.	
Ft.	In.	Ft.	In.				
0	0	351	0	Shale, sandstone, and thin coal beds.....	351	0	
351	0	378	0	Medium sandstone.....	27	0	
378	0	385	0	Interbedded sandstone and shale.....	7	0	
385	0	386	6	Sandstone.....	1	6	
386	6	387	0	Carbonaceous sandstone.....	0	6	
387	0	428	6	Medium sandstone.....	41	6	

Hole 19-28 (Cont'd.)

Depth				Material	Thickness		Remarks
From-		To-			Ft.	In.	
Ft.	In.	Ft.	In.				
428	6	431	3	COAL.....	2	9	
431	3	442	6	Gray shale.....	11	3	
442	6	443	6	Sandy shale.....	1	0	
443	6	450	6	Gray shale with veinlets of calcite.....	7	0	
450	6	460	9	COAL.....	10	3	
460	9	460	11	Bone.....	0	2	
460	11	461	7	Dirty COAL.....	0	8	
461	7	462	0	Carbonaceous shale.....	0	5	
462	0	466	0	Gray shale.....	4	0	
466	0	467	0	Fine sandstone.....	1	0	
467	0	467	6	Shaly sandstone.....	0	6	
467	6	479	4	Gray shale.....	1	10	
479	4	480	3	COAL.....	0	11	
480	3	481	0	Sandy bone.....	0	9	
481	0	482	10	Carbonaceous sandstone.....	1	10	Top of Rollins sandstone, 482 ft., 10 in.
482	10	524	0	Medium sandstone.....	41	2	

Hole 20-15

Location: 1,675 feet S. and 250 feet W. of N. E. corner, sec. 15, T. 13 S., R. 89 W.

Surface elevation: 7,635 feet.

Depth				Material	Thickness		Remarks
From-		To-			Ft.	In.	
Ft.	In.	Ft.	In.				
0	0	2138	0	Shale, sandstone, and thin coal beds.....	2138	0	
2138	0	2146	3	Interbedded sandstone and shale with halymenites.....	8	3	
2146	3	2150	3	Coal with nodules of sandstone from 2146 ft. 3 in. to 2146 ft. 8 in.	4	0	
2150	3	2150	6	Bone.....	0	3	
2150	6	2151	0	Carbonaceous shale with streaks of coal.....	0	6	
2151	0	2153	0	Black shale with plant remains ..	2	0	
2153	0	2163	10	Gray shale with streaks of coal and plant remains.....	10	10	
2163	10	2164	8	Sandy shale with plant remains and streaks of coal.	0	10	
2164	8	2170	4	Coal with vertical jointing..	5	8	
2170	4	2170	6	Bone.....	0	2	
2170	6	2177	7	Coal with diagonal jointing..	7	1	
2177	7	2178	4	Carbonaceous sandstone.....	0	9	Top of Rollins sandstone, 2,178 ft.
2178	4	2188	0	Medium sandstone.....	9	8	
1677							

R.I. 4104

Hole 21-23

Location: 2,100 feet S. and 1,200 feet W. of N. E. corner, sec. 23, T. 13 S., R. 89 W.

Surface elevation: 6,940 feet.

Depth				Material	Thickness		Remarks
From-		To-			Ft.	In.	
Ft.	In.	Ft.	In.				
0	0	1389	6	Shale, sandstone, and thin coal beds.....	1389	6	
1389	6	1399	9	Interbedded sandstone and shale.....	10	3	
1399	9	1401	7	COAL.....	1	10	
1401	7	1401	9	Coal with nodules of sandstone.....	0	2	
1401	9	1402	3	Carbonaceous sandstone.....	0	6	
1402	3	1415	6	Medium sandstone.....	13	3	
1415	6	1422	6	Dark shale with streaks of carbonaceous material.....	7	0	
1422	6	1428	11	Gray shale.....	6	5	
1428	11	1429	4	Carbonaceous shale and bone..	0	5	
1429	4	1429	6	Bone.....	0	2	
1429	6	1441	11	COAL.....	12	5	
1441	11	1442	0	Sandy bone.....	0	1	
1442	0	1442	4	Medium sandstone.....	0	4	
1442	4	1442	9	Carbonaceous sandstone.....	0	5	Top of Rollins sandstone, 1,442 ft. 9 in.
1442	9	1445	1	Fine, dark sandstone with carbonaceous material.....	2	4	
1445	1	1445	9	Sandy shale with plant remains and shaly sandstone...	0	8	
1445	9	1449	0	Fine, shaly sandstone.....	3	3	
1449	0	1450	4	Medium to fine sandstone.....	1	4	

Hole 22-4

Location: 200 feet N. and 1,250 feet E. of S. W. corner, sec. 4, T. 13 S., R. 89 W.

Surface elevation: 6,304 feet.

Depth				Material	Thickness		Remarks
From-		To-			Ft.	In.	
Ft.	In.	Ft.	In.				
0	0	807	0	Shale, sandstone, and thin coal beds.....	807	0	
807	0	829	0	Fine to medium sandstone with scattered halymenites.....	22	0	
829	0	831	6	Interbedded sandstone and shale.....	2	6	
831	6	834	4	Medium sandstone.....	2	10	

1677

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Hole 22-4 (Cont'd.)

Depth				Material	Thickness		Remarks
From-		To-			Ft.	In.	
Ft.	In.	Ft.	In.				
834	4	835	2	Carbonaceous sandstone.....	0	10	
835	2	838	0	COAL.....	2	10	
838	0	838	5	Soft, gray shale.....	0	5	
838	5	841	8	Carbonaceous shale.....	3	3	
841	8	846	0	Gray, sandy shale with plant remains.....	4	4	
846	0	847	0	Dark-brown shale with streaks of coal.....	1	0	
847	0	852	6	Mottled, shaly sandstone.....	5	6	
852	6	855	1	Sandy shale with streaks of coal from 854 ft., 11 in. to 855 ft., 1 in.	2	7	
855	1	857	0	COAL.....	1	11	
857	0	857	3	Bone.....	0	3	
857	3	859	9	Bentonitic shale with streaks of carbonaceous material....	2	6	
859	9	861	0	Carbonaceous shale and bone..	1	3	
861	0	862	3	Gray shale.....	1	3	
862	3	864	3	Bone.....	2	0	
864	3	865	2	Carbonaceous shale.....	0	11	
865	2	866	2	Gray shale.....	1	0	
866	2	867	0	Carbonaceous shale with streaks of coal.....	0	10	
867	0	871	0	Shaly sandstone.....	4	0	
871	0	871	9	Carbonaceous sandstone.....	0	9	
871	9	872	11	Shaly sandstone with streaks of carbonaceous material....	1	2	
872	11	873	9	COAL.....	0	10	
873	9	874	1	Bone.....	0	4	
874	1	874	7	Carbonaceous shale.....	0	6	
874	7	877	7	Dark shale.....	3	0	
877	7	879	8	Sandy shale.....	2	1	
879	8	885	0	Shaly sandstone.....	5	4	
885	0	887	0	Fine, shaly sandstone.....	2	0	
887	0	888	9	Carbonaceous shale.....	1	9	
888	9	890	4	COAL.....	1	7	
890	4	891	4	Carbonaceous shale.....	1	0	
891	4	892	10	COAL.....	1	6	
892	10	894	5	Sandy bone.....	1	7	
894	5	895	5	Carbonaceous sandstone.....	1	0	Top of Rollins sandstone, 895 ft., 5 in.
895	5	920	0	Medium sandstone.....	24	7	

R.I. 4104

Hole 23-4

Location: 3,300 feet N. and 2,800 feet E. of S. W. corner, sec. 4, T. 13 S.,
R. 89 W.

Surface elevation: 6,348 feet.

Depth				Material	Thickness		Remarks
From-		To-			Ft.	In.	
Ft.	In.	Ft.	In.				
0	0	1078	0	Shale, sandstone, and thin coal beds.....	1078	0	
1078	0	1086	6	Medium sandstone.....	8	6	
1086	6	1094	2	Interbedded sandstone and shale.....	7	8	
1094	2	1095	11	Coal with vertical jointing..	1	9	
1095	11	1096	3	Carbonaceous shale.....	0	4	
1096	3	1100	0	Gray shale with plant remains	3	9	
1100	0	1101	6	Carbonaceous shale.....	1	6	
1101	6	1104	0	Sandy shale and gray shale...	2	6	
1104	0	1110	9	Carbonaceous shale.....	6	9	
1110	9	1112	0	COAL.....	1	3	
1112	0	1113	7	Carbonaceous shale.....	1	7	
1113	7	1116	0	Gray sandy shale.....	2	5	
1116	0	1120	0	Fine sandstone with streaks of coal.....	4	0	
1120	0	1142	0	Medium cross-bedded sandstone with streaks of carbonaceous material.....	22	0	
1142	0	1142	11	COAL.....	0	11	
1142	11	1144	1	Carbonaceous shale.....	1	2	
1144	1	1146	2	Carbonaceous shale with streaks of coal.....	2	1	
1146	2	1146	10	Bone.....	0	8	
1146	10	1147	8	COAL.....	0	10	
1147	8	1149	1	Carbonaceous shale.....	1	5	
1149	1	1149	5	Bone.....	0	4	
1149	5	1152	9	COAL.....	3	4	
1152	9	1153	4	Bone.....	0	7	
1153	4	1154	2	Carbonaceous shale.....	0	10	
1154	2	1155	0	Sandy carbonaceous shale.....	0	10	
1155	0	1159	0	Sandstone with inclusions of carbonaceous material.....	4	0	Top of Rollins sandstone, 1,159 ft.
1159	0	1164	6	Thin bedded sandstone with shale partings.....	5	6	
1164	6	1180	0	Medium sandstone with shale breccia from 1,176 to 1,180 feet.....	15	6	

Hole 24-7

Location: 1,500 feet S. and 50 feet W. of the N. E. corner, sec. 7, T. 13
S., R. 89 W.

Surface elevation: 6,266 feet.

Depth				Material	Thickness		Remarks
From-		To-			Ft.	In.	
Ft.	In.	Ft.	In.				
0	0	503	0	Shale, sandstone, and thin coal beds.....	503	0	
503	0	578	1	Medium sandstone with abundant halymenites from 553 to 565 ft. and with thin shale partings (2-inch) from 575 to 578 ft.	75	1	
578	1	579	6	COAL.....	1	5	
579	6	581	3	Sandy, carbonaceous shale with streaks of coal.....	1	9	
581	3	583	1	Carbonaceous sandstone with streaks of coal.....	1	10	
583	1	641	0	Medium sandstone with halymenites.....	57	11	
641	0	647	6	Interbedded sandstone and shale.....	6	6	
647	6	659	0	Medium sandstone.....	11	6	
659	0	661	0	Interbedded sandstone and shale.....	2	0	
661	0	665	6	Fine sandstone.....	4	6	Top of Rollins sandstone, 583 ft.
665	6	670	0	Shaly sandstone.....	4	6	

