UNITED STATES DEPARTMENT OF THE INTERIOR

GEOLOGICAL SURVEY

Carbonera Coal Geophysical Logging Research Hole

Core Descriptions and Coal Analysis

By

R. G. Hobbs, J. L. Gualtieri, and R. N. Babcock

Open-File Report 82-827

Introduction

In 1980, the Branch of Coal Resources drilled two holes near Carbonera, Garfield County, Colorado. The pilot hole, Carbonera 1-R, was drilled in June to a depth of 815 feet (248.4 m) and was reported on by McPhillips (1980). It is located near the center of the E $\frac{1}{2}$ sec. 10, T. 7 S., R. 104 W., Garfield County, Colorado.

A second hole, Carbonera 1-C, was drilled to 945 feet (288.0 m), 826.4 feet (251.9 m) of which was cored. This report includes core descriptions, coal analysis, and other data from the second hole and research that has been conducted since McPhillips' report.

Geology

For details of the geology refer to Erdmann (1934) and Gualtieri (1979). The core description is shown in appendix A.

The formation and member tops and intervals drilled were surface to 652.6 feet (198.8 m) Mount Garfield Formation; upper Sego Sandstone 652.6-740.4 feet (198.8-225.7 m); Anchor Mine Tongue of the Mancos Shale 740.4-769.8 feet (225.7-234.6 m); upper Sego Sandstone 769.8-891.5 feet (234.6-271.7 m); and the Buck Tongue of the Mancos Shale 891.5 feet (271.7 m) to total depth (288.8 m).

Drilling

Carbonera 1-C was offset about 60 feet (18.3 m) east of the pilot hole Carbonera 1-R. Steel surface casing (6-inch (15.2-cm) inside diameter) was set and cemented at 15.8 feet (4.8 m). A 3-inch (7.62-cm) diameter core was taken from 15.8 to 842.2 feet (4.8 to 256.7 m), and core recovery was essentially 100 percent. The hole was rotary drilled from 842.2 to 945 feet (256.7 to 288.0 m), total depth.

Coal Analysis and Other Determinations

The proximate and ultimate analysis and Btu/lb (British thermal units per pound) determinations are shown in tables 1a and 1b. The apparent specific gravity, HGI (Hardgrove Grindability Index) and FSI (Free Swelling Index) are shown in table 2; the true specific gravity and FSI for four samples are shown in table 3; and the moist, mineral matter free Btu/lb, apparent rank and coal classifications are shown in table 4.

References

Erdmann, C. E., 1934, The Book Cliffs coal field in Garfield and Mesa Counties, Colorado: U.S. Geological Survey Bulletin 851, 150 p., 7 figs., 21 pls.

Goddard, E. N., chm., and others, 1948, Rock-color chart: National Research Council; reprinted by Geological Society of America, 6 p.

Gualtieri, J. L., 1979, Preliminary results of coal exploratory drilling in the Book Cliffs coal region, Garfield County, Colorado and Grand County, Utah: U.S. Geological Survey Open-File Report 79-999, 57 p., 5 oversize sheets.

McPhillips, M., 1980, Preliminary report on a coal exploratory drill hole in the Book Cliffs coal region, Garfield County, Colorado: U.S. Geological Survey Open-File Report 80-940, 7 p.

Table 1a.--Proximate, ultimate analysis and Btu/lb, with equilibrium moisture for the Carbonera, Cameo, Ballard and Palisade coals

[Leaders (---) indicate no data]

Coal Zone	Interval (ft)	Analysis basis	Proximate analysis					Ultimate analysis					
			H_2O	VM	FC	Ash	Btu/lb	C	H	N	Cl	O	S
Carbonera	225.4-228.0 (2.6)	As rec'd[1]	11.10	33.18	41.32	14.40	10,506	58.21	4.57	1.56	0.01	9.58	0.57
		Eq moist[2]	Same as "As received"										
		Dry	---	37.32	46.48	16.20	11,818	65.48	5.14	1.75	0.01	10.78	0.64
		dmmf[3]	---	44.53	55.47	---	14,103	78.14	6.13	2.09	0.01	12.86	0.76
Cameo Upper	299.9-300.9 (1.0)	As rec'd	7.34	31.48	42.83	18.35	10,147	58.27	4.07	1.28	0.01	10.25	0.43
		Eq moist	9.90	30.61	41.65	17.84	9,867	56.66	3.96	1.24	0.01	9.97	0.42
		Dry	---	33.97	46.23	19.80	10,951	62.89	4.39	1.38	0.01	11.07	0.46
		dmmf	---	42.36	57.64	---	13,655	78.43	5.47	1.72	0.01	13.80	0.57
	300.9-304.5 (3.6)	As rec'd	13.09	32.74	45.38	8.79	11,087	62.91	4.37	1.42	0.02	8.98	0.42
		Eq moist	10.76	33.60	46.64	9.00	11,384	64.60	4.50	1.46	0.02	9.22	0.44
		Dry	---	37.67	52.22	10.11	12,757	72.39	5.03	1.63	0.02	10.34	0.48
		dmmf	---	41.91	58.09	---	14,192	80.53	5.60	1.81	0.02	11.50	0.53
Cameo Lower	305.5-307.5 (2.0)	As rec'd	8.61	36.74	48.08	6.57	11,848	67.14	4.74	1.60	0.00	10.77	0.57
		Eq moist	10.70	35.90	46.98	6.42	11,577	65.60	4.63	1.56	0.00	10.77	0.56
		Dry	---	40.20	52.61	7.19	12,694	73.46	5.19	1.75	0.00	11.79	0.62
		dmmf	---	43.31	56.69	---	13,968	79.15	5.59	1.89	0.00	12.70	0.67
	307.5-310.1 (2.6) Includee 1.0 ft shale parting on top	As rec'd	10.64	26.60	30.00	32.76	7,647	42.90	3.40	1.06	0.00	8.71	0.53
		Eq moist	9.63	26.90	30.30	33.17	7,732	43.36	3.43	1.07	0.00	8.80	0.54
		Dry	---	29.77	33.57	36.66	8,557	48.02	3.81	1.19	0.00	9.74	0.59
		dmmf	---	47.00	53.00	---	13,510	75.80	6.02	1.88	0.00	15.38	0.92
Ballard(?)	456.6-458.8 (2.2)	As rec'd	11.57	31.73	43.33	13.37	10,720	60.92	4.14	1.53	0.00	8.00	0.47
		Eq moist	10.63	32.10	43.70	13.60	10,865	61.54	4.18	1.54	0.00	8.07	0.47
		Dry	---	35.88	49.00	15.12	12,123	68.89	4.68	1.73	0.00	9.05	0.53
		dmmf	---	42.27	57.73	---	14,283	81.16	5.51	2.04	0.00	10.66	0.62
Palisade	599.8-600.8 (1.0)	As rec'd	7.94	14.69	9.15	68.22	2,706	16.02	1.68	0.41	0.03	5.36	0.34
		Eq moist	6.71	Not calculated				---	---	---	---	---	---
		Dry	---	15.96	9.94	74.10	2,939	17.40	1.82	0.44	0.03	5.84	0.37
		dmmf	Not calculated					---	---	---	---	---	---
	600.8-602.2 (1.4)	As rec'd	11.06	34.12	48.99	5.83	12,035	67.85	4.64	1.74	0.00	8.27	0.61
		Eq moist	9.73	34.90	49.50	5.87	12,351	68.88	4.73	1.77	0.00	8.40	0.62
		Dry	---	38.36	55.80	6.56	13,532	76.29	5.22	1.96	0.00	9.28	0.69
		dmmf	---	41.05	58.95	---	14,482	81.65	5.59	2.10	0.00	9.93	0.74

[1] As received.

[2] Equilibrium moisture.

[3] Dry, mineral-matter free.

Table 1b.--Proximate and ultimate analyses and Btu/lb (moisture questionable) of Cameo coals

[Leaders (---) indicate no data]

Coal zone	Interval (ft)	Analysis basis	Proximate					Ultimate				Sulphur			
			H_2O	VM	FC	Ash	Btu/lb	C	H	N	O	O	Sulf.	Pyr.	Org.
Cameo, rider	293.5-294.5	As rec'd[1/]	8.45	35.81	49.63	6.11	11,828	68.02	5.49	1.58	18.29	0.51	0.01	0.06	0.44
		Eq moist[2/]		Not determined			---	---	---	---	---	---	---	---	---
		dry	---	39.12	54.20	6.68	12,920	74.29	4.96	1.72	11.79	0.56	0.01	0.06	0.46
		dmmf[3/]	---	41.92	58.08	---	13,845	79.61	5.31	1.84	12.64	0.60	0.01	0.06	0.53
Cameo, rider	294.5-295.5	As rec'd	7.07	35.93	46.29	10.71	11,129	64.31	5.26	1.53	17.71	0.48	0.01	0.02	0.45
		Eq moist		Not determined			---	---	---	---	---	---	---	---	---
		dry	---	38.66	49.82	11.52	11,976	69.21	4.81	1.65	12.29	0.52	0.01	0.02	0.49
		dmmf	---	43.69	56.31	---	13,535	78.22	5.44	1.86	13.89	0.59	0.01	0.02	0.56
Cameo, lower	307.5-308.5	As rec'd	6.11	28.80	38.32	26.77	9,229	52.78	4.35	1.27	14.35	0.48	0.01	0.01	0.46
		Eq moist		Not determined			---	---	---	---	---	---	---	---	---
		dry	---	30.68	40.81	28.51	9,829	56.21	3.90	1.35	9.52	0.51	0.01	0.01	0.49
		dmmf	---	42.92	57.08	---	13,750	78.63	5.46	1.89	13.31	0.71	0.01	0.01	0.69
Cameo, lower	310.1-310.7	As rec'd	5.90	35.14	43.91	15.05	10,986	62.23	5.07	1.46	15.51	0.68	-0.01	0.02	0.60
		Eq moist		Not determined			---	---	---	---	---	---	---	---	---
		dry	---	37.34	46.66	16.00	11,675	66.13	4.69	1.55	10.91	0.72	-0.01	0.02	0.70
		dmmf	---	44.45	55.55	---	13,898	78.72	5.58	1.85	12.99	0.86	-0.01	0.02	0.84

1/ As received.

2/ Equilibrium moisture.

3/ Dry, mineral-matter free.

Table 2.--Apparent Specific Gravity, FSI (Free Swelling Index), and HGI (Hardgrove Grindability Index)

[Leaders (---) indicate no data]

Coal bed	Interval (ft)	Apparent Specific Gravity						FSI	HGI	
		Dried		As received		Equilibrium moisture			Index	Moisture level
		g/c^3	% moisture	g/c^3	% moisture	g/c^3	% moisture			
Carbonera	225.4-228.0	1.37	5.44	1.35	11.10	1.35	11.10	1.5	48.2	4.36
Cameo										
Upper	299.9-300.9	---	---	1.33	7.34	---	9.90	---	---	---
	300.9-304.5	1.36	8.67	1.34	13.09	1.35	10.76	1.5	44.2	6.87
Lower	305.5-307.5	---	---	1.32	8.61	---	10.70	---	---	---
	307.5-310.1	1.60	6.95	1.58	10.64	1.59	9.63	0.5	48.2	5.60
Ballard(?)	456.6-458.8	1.40	6.15	1.38	11.57	1.38	10.63	---	46.0	4.80
Palisade	599.8-600.8	2.21	1.27	2.13	7.94	2.15	6.71	0.0	63.8	1.63
	600.8-602.2	1.33	6.74	1.31	11.06	1.32	9.73	3.0	44.6	5.26

Table 3.--True Specific Gravity and FSI (Free Swelling Index) samples

Coal zone	Interval (ft)	Specific gravity (g/c^3)	FSI
Cameo, rider	293.5-294.5	1.39	0.5
	294.5-295.5	1.41	0.5
Cameo, lower	307.5-308.5	1.56	0.5
	310.1-310.7	1.44	1.0

Table 4.--Moist, Mineral-Matter Free Btu/lb and Apparent Rank

[Samples with moisture questionable; table 1b, not ranked]

Coal bed	Interval (ft)	Moist, mineral matter free Btu/lb	Apparent rank
Carbonera	225.4-228.0	12,465	High volatile C-Bituminous
Cameo			
Upper	299.9-300.9	12,316	High volatile C-Bituminous
	300.9-304.5	12,587	High volatile C-Bituminous
Lower	305.5-307.5	12,473	High volatile C-Bituminous
	307.5-310.1	12,062	High volatile C-Bituminous
Ballard(?)	456.6-458.8	12,747	High volatile C-Bituminous
Palisade	599.8-600.8	---	Not ranked
	600.8-602.2	13,207	High volatile B-Bituminous

Appendix A
Core Description

U.S. Geological Survey
Branch of Coal Resources

Project Carbonera Borehole Geology and Geophysical Logging Research

Hole No. Carbonera 1-C Geologist J. L. Gualtieri and R. G. Hobbs

Type log. Core Description Elev. 5808 (AMSL) ft Total depth 945 ft

Location 420 FEL, 2625 FNL Sec. 10 T. 7 S. R. 104 W.

Nearest town Mack County Garfield State Colo. Quad. Carbonera 7.5-minute

Drilled by: USGS - Branch of Coal Resources, Denver, CO

Driller(s): Arthur Clark (driller), Larry Kozak and Gerald Rott (helpers)

Drill rig: Gardner-Denver 17W Date start 10/20/80 Complete 10/28/80

Non-core intervals and size hole: 0 to 15.8 ft, and 842.2 to 945.0 ft; 5-1/8 inch

Cored intervals and size: 15.8 to 842.2 ft; 3-inch diameter core

Remarks: Core descriptions correlated to geophysical log by R. G. Hobbs. Geophysical logs include natural gamma, density (various types) resistivity (single point), 16" normal, sonic, neutron, caliper, deviation and continuous diameter, induced polarity and self potential

Log

From (ft)	To (ft)	Thick-ness (ft)	Description
			[Color designations from Goddard and others, 1948. Most core dry; some sandstone wet from having been halved by means of diamond saw. All depths and thicknesses given in feet; 1 foot equals .3048 meter]
			Cretaceous:
			Mount Garfield Formation:
0	15.8	15.8	Rotary drilled: some colluvium, and mostly bedrock
			Core description 15.8 ft to 842.2 ft
15.8	16.4	0.6	Siltstone, poorly laminated, moderate-yellowish brown (10 YR 5/4); contact with underlying unit gradational

Log Continuation: Hole No.: Carbonera 1-C

 Project: Carbonera Borehole

Log

From (ft)	To (ft)	Thick-ness (ft)	Description
16.4	24.7	8.3	Sandstone, well to poorly laminated, silty to shaley in parts, very fine grained, dark-yellowish-orange (10 YR 6/6) to moderate-yellowish-brown (10 YR 5/4); contains abundant dark opaque mineral grains, sparse mica flakes, and sparse to abundant carbonaceous films and flakes. Laminae slightly inclined, slump-folded in parts where silty or shaley
24.7	31.7	7.0	Core missing
31.7	38.9	7.2	Sandstone, poorly to well laminated, very fine grained, medium-light-gray (N6) and yellowish-gray (5 Y 7/2); contains medium-gray, angular to ragged bodies, lenses, and pods of shale throughout commonly less than an inch long, some permeated with limonite, and abundant carbonaceous films and flakes in one part. Sandstone laminae inclined as much as 30°
38.9	39.2	0.3	Shale, yellowish-gray (5 Y 7/2) mottled grayish-orange (10 YR 7/4); contains sparse carbonaceous films. Contact with underlying unit abrupt, inclined
39.2	40.5	1.3	Sandstone, poorly laminated, very fine grained, yellowish-gray (5 Y 7/2); contains sparse carbonaceous films near base

Log Continuation: Hole No.: Carbonera 1-C

 Project: Carbonera Borehole

Log

From (ft)	To (ft)	Thick-ness (ft)	Description
40.5	42.5	2.0	Shale, silty in part, medium-dark-gray (N4) to light-gray (N7), mottled moderate-yellowish-brown (10 YR 5/4) in parts
42.5	43.0	0.5	Coal, impure, black (N1) and grayish-black (N2); contains vitrain lenses as thick as .005 ft; cleat not apparent. Nearly horizontal slickensided surfaces in parts
43.0	44.3	1.3	Siltstone and sandstone, interlaminated; siltstone, medium-gray (N5); sandstone, very fine grained, medium-gray (N5). Unit contains sparse carbonaceous films and steeply inclined slickensided surface in upper part. Contact with underlying unit gradational
44.3	48.5	4.2	Shale and siltstone, interbedded, medium-gray (N5); contains moderate amounts of carbonaceous films in parts
48.5	49.5	1.0	Shale, dark-gray (N3) and grayish-black (N2), highly carbonaceous
49.5	50.6	1.1	Sandstone, well laminated, very fine grained, light-gray (N7) to light-olive-gray (5 Y 6/1), mottled grayish-orange (10 YR 7/4); contains abundant opaque mineral grains, sparse mica flakes. Laminae disrupted, bioturbated
50.6	51.0	0.4	Siltstone, moderate-yellowish-brown (10 YR 5/4)
51.0	51.6	0.6	Shale, olive-gray (5 Y 4/1), mottled moderate-yellowish-brown (10 YR 5/4); contact with underlying unit slightly undulatory

Log

From (ft)	To (ft)	Thick-ness (ft)	Description
51.6	86.3	34.7	Sandstone, well to poorly laminated, limey, fine-grained in uppermost part, grading downward to fine-grained, and to very fine grained near base, grayish-orange (10 YR 7/4) to dark-yellowish-brown (10 YR 4/2) in most parts, light-gray (N7) and very light gray (N8) near base; contains abundant dark and light opaque mineral grains, sparse mica flakes, and moderate to abundant carbonaceous films and flakes in some parts; ragged moderate-brown (5 YR 4/4) (limonitic or pyritic) flake-like bodies associated with carbonaceous material in parts. Laminae horizontal or slightly inclined. Steeply inclined fractures in lower part, some healed with calcite, others with limonite-coated surfaces, slickensided fracture filled with calcite at 81+ ft
86.3	89.6	3.3	Shale, silty, and shaley siltstone, poorly laminated, medium-dark-gray (N4); contains sparse to abundant carbonaceous films and flakes. Pyrite and scaley bodies of noncalcareous (selenite?) mineral associated with carbonaceous material
89.6	90.8	1.2	Core missing
90.8	91.6	0.8	Mudstone, unlaminated, grayish-black (N2); highly carbonaceous

Log Continuation: Hole No.: Carbonera 1-C

 Project: Carbonera Borehole

Log

From (ft)	To (ft)	Thickness (ft)	Description
91.6	92.2	0.6	Siltstone, poorly laminated, light-olive-gray (5 Y 6/1); contains sparse carbonaceous films
92.2	93.3	1.1	Shale, silty, and siltstone, medium-dark-gray (N4); contains moderate amounts of carbonaceous films
93.3	94.3	1.0	Sandstone and siltstone, bioturbated, medium-light-gray (N6); contains sparse carbonaceous films. Laminae evident but bioturbated
94.3	101.5	7.2	Shale and silty shale, mostly dark-gray (N3), medium-dark-gray (N4) in parts, moderately carbonaceous; contains vitrain lenses as thick as .02 ft and sparse moderate-yellow (5 Y 7/6) bodies in lower part. Contact with underlying unit gradational
101.5	108.8	7.3	Siltstone, shaley in parts, well to poorly laminated and bioturbated, medium-gray (N5) to dark-gray (N3), moderately carbonaceous; contains interlaminae of sandstone in upper and lower parts. Unit becomes more carbonaceous downward. Contact with underlying unit abrupt
108.8	120.7	11.9	Sandstone, silty in parts, laminated in some parts, and bioturbated in other parts, very fine grained, medium-gray (N5); contains abundant dark opaque mineral grains, carbon-rich laminae, irregular ragged shale lenses, and siltstone laminae

Log

From (ft)	To (ft)	Thickness (ft)	Description
120.7	120.9	0.2	Siltstone and sandstone, interlaminated and bioturbated; siltstone, grayish-black (N2), highly carbonaceous; sandstone, very fine grained, medium-gray (N3)
120.9	122.7	1.8	Siltstone, medium-dark-gray (N4), grayish-orange (10 YR 7/4) at one place near top, moderately carbonaceous. Contact with underlying unit gradational
122.7	124.0	1.3	Shale, silty, grayish-black (N2) and brownish-black (5 YR 2/1), highly carbonaceous. Contact with underlying unit gradational
124.0	125.6	1.6	Siltstone, shaley in parts, medium-gray (N5), slightly to moderately carbonaceous; contains sparse to abundant carbonaceous films and flakes. Contact with underlying unit gradational
125.6	126.7	1.1	Sandstone and siltstone, interlaminated; sandstone, very fine grained, medium-gray (N5); siltstone, medium-dark-gray (N4). Unit contains moderate amounts of carbonaceous films and flakes. Laminae distinct but disrupted in parts. Contact with underlying unit gradational
126.7	127.6	0.9	Siltstone, sandy, obscurely laminated, olive-gray (5 Y 2/1); contains sparse carbonaceous films and flakes. Contact with underlying unit abrupt

Log

From (ft)	To (ft)	Thick-ness (ft)	Description
127.6	129.2	1.6	Siltstone, shaley, medium-gray (N5); contains sparse to moderately abundant carbonaceous films and flakes. Contact with underlying unit gradational
129.2	132.5	3.3	Core missing
132.5	135.9	3.4	Sandstone, poorly laminated, very fine grained, light-olive-gray (5 Y 6/1); contains abundant dark opaque mineral grains and sparse to moderate amounts of carbonaceous films and flakes
135.9	138.2	2.3	Siltstone and sandstone, interlaminated and interbedded; siltstone, medium-gray (N5); sandstone, very fine grained, light-gray (N7). Unit well laminated and bedded; laminae disrupted in part
138.2	139.7	1.5	Shale and impure coal, grayish-black (N2) and black (N1); shale highly carbonaceous; contains vitrain lenses as thick as .05 ft. Contact with underlying unit gradational
139.7	141.1	1.4	Shale, silty, and shaley siltstone, mostly dark-gray (N3), medium-light-gray (N6) in parts, moderately carbonaceous; contains abundant carbonaceous films and flakes throughout, and a single vitrain lens .02 ft thick in upper part. Contact with underlying unit gradational

Log

From (ft)	To (ft)	Thickness (ft)	Description
141.1	149.5	8.4	Sandstone and siltstone, parts interlaminated and interbedded, and other parts bioturbated; sandstone, very fine grained, medium-light-gray (N6); siltstone, medium-gray (N5) and light-brownish-gray (5 Y 6/1). Sandstone contains abundant carbon-rich laminae. Laminae disturbed, bioturbated
149.5	151.1	1.6	Shale, silty, medium-gray (N5), sandy in upper part
151.1	151.7	0.6	Sandstone, well laminated, very fine grained, very light gray (N8); contains abundant carbon-rich laminae. Laminae microfolded and microfaulted
151.7	152.0	0.3	Shale, silty, medium-dark-gray (N4), moderately carbonaceous
152.0	152.5	0.5	Siltstone, fractured, brownish-gray (5 YR 4/1). Fracture surfaces covered with white calcite
152.5	154.0	1.5	Siltstone, shaley, medium-dark-gray (N4)
154.0	154.6	0.6	Shale, and impure coal, grayish-black (N2) and black (N1); shale highly carbonaceous; contains high-angle slickensided surfaces. Contact with underlying coal abrupt
154.6	155.7	1.1	Coal, black (N1), banded, elongated, splinter-like; contains vitrain lenses .01 ft or less thick. White noncalcareous scale on fracture surfaces. Uppermost 0.5 ft impure to shaley. Basal contact abrupt

Log

From (ft)	To (ft)	Thick-ness (ft)	Description
155.7	156.5	0.8	Shale, grayish-black (N2), highly carbonaceous
156.5	157.5	1.0	Coal, black (N1), banded, vitrainous and attrital; contains vitrain lenses less than .01 ft thick; cleat well developed, spaced about .1 ft. Roof and floor contacts abrupt
157.5	157.6	0.1	Coal, impure, black (N1) and grayish-black (N2)
157.6	159.9	2.3	Siltstone, shaley, brownish-gray (5 YR 4/1), moderately carbonaceous; contains sparse to abundant carbonaceous films and flakes, and single vitrain lens .05 ft thick
159.9	160.5	0.6	Sandstone, very fine grained, very light gray (N8). Contact with underlying unit gradational
160.5	191.4	30.9	Sandstone and siltstone, interlaminated and interbedded; sandstone, very fine grained, light-brownish-gray (5 YR 6/1) to light-olive-gray (5 Y 6/1); siltstone, brownish-gray (5 YR 4/1), slightly to moderately carbonaceous. Laminae disrupted and bioturbated in parts. Unit contains abundant carbon-rich laminae. Sandstone-siltstone ratio differs throughout unit with sandstone content generally increasing downward. Contact with underlying unit gradational

Log

From (ft)	To (ft)	Thickness (ft)	Description
191.4	213.7	22.3	Sandstone, poorly laminated, very fine grained, light-gray (N7); contains abundant dark opaque mineral grains, some intermixed bioturbated medium-gray siltstone, and abundant carbon-rich laminae in basal part
213.7	213.8	0.1	Coal, black (N1), banded, vitrainous and attrital; contains vitrain lenses commonly .01 ft or less thick. Cleat not apparent
213.8	223.3	9.5	Shale, medium-dark-gray (N4); contains disrupted, bioturbated laminae of sandstone in basal part
223.3	225.4	2.1	Sandstone and siltstone, bioturbated; sandstone, very fine grained, yellowish-gray (5 Y 8/1); siltstone, medium-gray (N5)
225.4	228.0	2.6	Coal, black (N1), banded, vitrainous, attrital, elongated splinter-like fracture. Upper part of coal scoured, very fine grained, wavy, cross-stratified carbonaceous sandy mudstone. Scour cuts coal at about 30° angle
228.0	229.0	1.0	Shale, grayish-black (N2) and brownish-black (5 YR 2/1), highly carbonaceous; contains abundant vitrain lenses in parts
229.0	231.0	2.0	Shale, medium-gray (N3); contains sparse to moderate amounts of carbonaceous films

Log

From (ft)	To (ft)	Thickness (ft)	Description
231.0	233.7	2.7	Sandstone, poorly laminated, slightly friable, very fine grained, medium-light-gray (N6), contains abundant carbon-rich laminae. Contact with underlying unit abrupt
233.7	235.3	1.6	Sandstone, well to poorly laminated, tightly cemented, very fine grained, light-gray (N7); contains moderate amounts of light and dark opaque mineral grains and carbon-rich laminae. Laminae inclined at low angles. Contact with underlying unit gradational
235.3	244.9	9.6	Sandstone, well to poorly laminated, very fine grained, light-gray (N7); contains abundant dark opaque mineral grains, and sparse to very abundant carbon-rich laminae
244.9	245.1	0.2	Coal, impure and siltstone, brownish-black (5 YR 2/1); siltstone highly carbonaceous; contains vitrain lenses as thick as .02 ft. Contact with underlying unit gradational
245.1	246.7	1.6	Sandstone and siltstone, intermixed; sandstone, very fine grained, brownish-gray (5 YR 4/1); siltstone, darker than brownish-gray (5 YR 4/1); contains vitrain lenses as thick as .01 ft
246.7	248.0	1.3	Coal, black (N1), banded, vitrainous and attrital, contains vitrain lenses as thick as .01 ft; cleat not apparent

Log

From (ft)	To (ft)	Thick-ness (ft)	Description
248.0	269.5	21.5	Shale, silty, brownish-black (5 YR 2/1) grading downward to brownish-gray (5 YR 4/1) and grayish-black (N2), highly to moderately carbonaceous; contains vitrain lenses in middle part, some as thick as .02 ft, and some brownish-gray (5 YR 4/1) siltstone and slickensided surfaces in basal part
269.5	270.1	0.6	Coal, black (N1), shaly
270.1	271.2	1.1	Coal, black (N1), vitrainous and attrital; contains vitrain lenses commonly less than .01 ft thick; cleat not apparent
271.2	274.2	3.0	Siltstone and sandstone, bioturbated; siltstone, medium-gray (N5); sandstone, very fine grained, medium-gray (N5). Unit contains sparse carbonaceous films and flakes. Contact with underlying unit gradational
274.2	275.5	1.3	Sandstone, massive, bioturbated, very fine grained, medium-light-gray (N6) and pinkish-gray (5 YR 3/1); contains sparse wispy bodies of carbon-impregnated sandstone oriented vertical or at high angles. Contact with underlying unit abrupt. Root zone near base
275.5	280.2	4.7	Shale, silty, and shaley siltstone, medium-dark-gray (N4) and dark-gray (N3), moderately to highly carbonaceous. Contact with underlying unit abrupt

Log

From (ft)	To (ft)	Thick-ness (ft)	Description
280.2	285.4	5.2	Siltstone, massive or poorly laminated, bioturbated, brownish-gray 5 YR (4/1); contains some intermixed sandstone in lower part, and abundant carbonaceous films and flakes throughout. Contact with underlying unit gradational
285.4	292.0	6.6	Shale, silty, poorly laminated, grayish-black (5 YR 2/1), highly carbonaceous, grading downward to medium gray (N5), moderately carbonaceous. Sparse carbonaceous plant fragments barely visible
292.0	293.0	1.0	Shale, silty, grading downward to nonsilty shale, grayish-black (N2), highly carbonaceous
293.0	295.0	2.0	Coal, black (N1), banded, vitrainous and attrital; vitrain lenses as thick as .02 ft; cleat not apparent. Uppermost 0.2 ft shaly and impure
295.0	295.7	0.7	Shale, grayish-black (N2) and brownish-black (5 YR 2/1); contains abundant vitrain lenses, some as thick as .01 ft
295.7	298.8	3.1	Shale and siltstone, bioturbated; shale, medium-dark-gray (N4); siltstone, light-gray (N7). Unit moderately carbonaceous
298.8	299.1	0.3	Sandstone, silty, massive, very fine grained, medium-dark-gray (N4)

Log Continuation: Hole No.: Carbonera 1-C

 Project: Carbonera Borehole

Log

From (ft)	To (ft)	Thick-ness (ft)	Description
299.1	299.9	0.8	Shale and siltstone, bioturbated; shale, medium-dark-gray (N4); siltstone, medium-light-gray (N6) to very light gray (N8)
299.9	304.5	4.6	Coal, black (N1), banded, vitrainous and attrital, very hard; parallel cleat spaced .1 ft; very bright coal .01 ft thick interbedded with bright coal .04 ft thick. Roof contact flat, floor contact inclined. Gypsum rosettes on fractures
304.5	305.5	1.0	Shale, grayish-black (N2), highly carbonaceous; uppermost .15 ft possibly tonstein
305.5	310.7	5.2	Coal, black (N1), vitrainous and attrital, cleat and butt fracture well developed; uppermost 0.1+ ft shaley to bony; shale parting 307.5 ft to 308.4 ft
310.7	311.5	0.8	Siltstone, brownish-black (5 YR 2/1), highly carbonaceous; contact with underlying unit gradational
311.5	316.5	5.0	Sandstone, poorly to well laminated, bioturbated in parts, very fine grained, light-gray (N7) to medium-dark-gray (N4); contains very abundant carbon-rich laminae in parts, some wispy, vertically oriented carbonaceous films in upper part--root zone

Log Continuation: Hole No.: Carbonera 1-C

 Project: Carbonera Borehole

Log

From (ft)	To (ft)	Thick-ness (ft)	Description
316.5	322.0	5.5	Siltstone, brownish-gray (5 YR 4/1) to brownish-black (5 YR 2/1), moderately to highly carbonaceous; contains vitrain lenses in uppermost and basal parts, light-gray (N7), laminated sandstone in upper-middle part
322.0	322.1	0.1	Coal, black (N1), banded, vitrainous and attrital
322.1	322.2	0.1	Shale, brownish-black (5 YR 2/1), highly carbonaceous
322.2	322.6	0.4	Coal, black (N1), banded, vitrainous and attrital; contains vitrain lenses as thick as .01 ft; cleat poorly developed, spaced about .1 ft
322.6	322.8	0.2	Coal, impure, brownish-black (5 YR 2/1)
322.8	328.7	5.9	Siltstone, sandy, poorly laminated, bioturbated, brownish-gray (5 YR 4/1) to dark-gray (N3), moderately carbonaceous; contains abundant carbonaceous films and flakes
328.7	333.7	5.0	Sandstone, laminated to slightly bioturbated, very fine grained, light-olive-gray (5 Y 6/1); contains abundant carbon-rich laminae, slumped in lower part. Contact with underlying unit gradational
333.7	334.7	1.0	Siltstone, brownish-black (5 YR 2/1), highly carbonaceous; contact with underlying unit gradational

Log

From (ft)	To (ft)	Thick-ness (ft)	Description
334.7	335.4	0.7	Sandstone, bioturbated in upper part, very fine grained, light-gray (N7); contains abundant carbon-rich laminae
335.4	335.8	0.4	Coal, black (N1), banded, vitrainous and attrital; vitrain lenses less than .01 ft thick; cleat poorly developed
335.8	336.1	0.3	Coal, impure and highly carbonaceous shale, brownish-black (5 YR 2/1); contains vitrain lenses as thick as 0.2 ft
336.1	340.9	4.8	Sandstone, mostly well laminated, very fine grained, light-gray (N7); contains abundant carbon-rich laminae
340.9	341.0	0.1	Shale, dark-gray (N3), moderately carbonaceous
341.0	342.0	1.0	Coal, black (N1), banded, vitrainous and attrital; vitrain lenses as thick as .1 ft; cleat moderately well developed, spaced .06 to .8 ft; pyrite scale on cleat face near base
342.0	342.4	0.4	Shale, brownish-black (5 YR 2/1), highly carbonaceous; contains minor bioturbated sandstone
342.4	351.8	9.4	Sandstone, poorly to well laminated, very fine grained, light-olive-gray (5 Y 6/1); contains moderate amounts of dark opaque mineral grains, very sparse mica flakes, and moderate to very abundant carbon-rich laminae, uppermost part highly bioturbated. Contact with underlying unit abrupt

Log

From (ft)	To (ft)	Thickness (ft)	Description
351.8	352.0	0.2	Coal, black (N1), banded, vitrainous and attrital; vitrain lenses as thick as .01 ft; cleat poorly developed or absent
352.0	353.5	1.5	Shale, brownish-black (5 YR 2/1), highly carbonaceous becoming less so downward; contains bioturbated sandstone in basal part; contact with underlying unit gradational
353.5	375.4	21.9	Sandstone, well laminated, bioturbated in parts, very fine grained, mostly light-gray (N7); contains abundant dark opaque mineral grains, sparse to very abundant carbon-rich laminae, and sparse interbeds of pale-yellowish-brown (10 Y 6/2) siltstone and brownish-black (5 YR 2/1) shale. Contact with underlying unit gradational
375.4	375.7	0.3	Shale, brownish-black (5 YR 2/1), highly carbonaceous; contains few sandstone lenses
375.7	376.5	0.8	Coal, black (N1), banded, vitrainous and attrital; vitrain lenses less than .005 ft thick; cleat well developed, spaced .04 to .08 ft; pyrite scale on cleat faces in uppermost part
376.5	388.5	12.0	Shale, silty, dark-gray (N3) to grayish-black (N2), moderately to highly carbonaceous; contains abundant disrupted sandstone laminae, lenses, and beds, and few vitrain lenses in upper part, some as thick as .04 ft

Log

From (ft)	To (ft)	Thickness (ft)	Description
388.5	389.5	1.0	Coal, black (N1), banded, vitrainous and attrital; vitrain lenses as thick as .01 ft, commonly less; cleat moderately well developed, spaced .1 ft or less
389.5	390.4	0.9	Shale, brownish-black (5 YR 2/1), highly carbonaceous; contains moderate amounts of vitrain lenses in upper part; lenses less than .01 ft thick
390.4	391.1	0.7	Siltstone, brownish-gray (5 YR 4/1), moderately carbonaceous; contains moderate amounts of light-gray bioturbated sandstone lenses
391.1	392.9	1.8	Sandstone, laminated, very fine grained, medium-gray (N5); contains abundant dark opaque mineral grains, abundant carbon-rich laminae, and some siltstone lenses
392.9	396.8	3.9	Sandstone and siltstone, interlaminated, bioturbated in parts; sandstone, very fine grained, light-gray (N7); siltstone, brownish-gray (5 YR 4/1) and in parts dark-yellowish-brown (10 YR 4/2); contains sparse carbonaceous films
396.8	399.3	2.5	Shale, silty, dark-gray (N3), moderately carbonaceous; contact gradational with underlying unit

Log

From (ft)	To (ft)	Thick-ness (ft)	Description
399.3	402.0	2.7	Sandstone, shaley siltstone, and silty shale, bioturbated, laminated in lower part; sandstone, very fine grained, very light gray (N8) and light-gray (N7); siltstone and shale, medium-dark-gray (N4) and dark-gray (N3), moderately carbonaceous. Sandstone dominant. Contact with underlying unit gradational
402.0	407.3	5.3	Shale, dark-gray (N3), moderately carbonaceous; contains few sandstone lenses in upper part. Contact with underlying unit abrupt
407.3	410.6	3.3	Sandstone and silty shale, interbedded and interlaminated, bioturbated in parts; sandstone, light-olive-gray (5 Y 6/1) and moderate-yellowish-brown (10 YR 5/4) in parts; shale, dark-gray (N3) to brownish-black (5 YR 2/1), moderately carbonaceous. Contact with underlying unit gradational
410.6	428.3	17.7	Shale, silty, medium-dark-gray (N4), moderately carbonaceous; contains some sandstone lenses and sandstone in parts, and sparse pale-yellowish-brown (10 YR 6/2) siltstone. Contact with underlying unit gradational

Log

From (ft)	To (ft)	Thickness (ft)	Description
428.3	430.2	1.9	Sandstone and silty shale, interlaminated and bioturbated; sandstone, very fine grained, very light gray (N8); shale, dark-gray (N3), moderately carbonaceous. Unit contains minor pale-yellowish-brown (10 YR 6/2) siltstone. Contact with underlying unit gradational
430.2	431.3	1.1	Shale, silty and shaley siltstone, medium-dark-gray (N4), moderately carbonaceous; contains some carbonaceous films. Contact with underlying unit gradational
431.3	432.4	1.1	Sandstone and siltstone, interlaminated and bioturbated; sandstone, very fine grained, very light gray (N8); siltstone, medium-dark-gray (N4), moderately carbonaceous. Contact with underlying unit abrupt
432.4	438.9	6.5	Sandstone, fine-grained to very fine grained; light-gray (N7); contains dark and light opaque mineral grains, sparse mica flakes where fine-grained, abundant carbon-rich laminae, and some brownish-gray (5 YR 4/1) siltstone. Contact with underlying unit gradational
438.9	441.1	2.2	Siltstone and sandstone, interlaminated and bioturbated; sandstone, very fine grained, very light gray (N8); siltstone, medium-dark-gray (N4), and moderate-yellowish-brown (10 YR 5/4) in few places, moderately carbonaceous. Contact with underlying unit gradational

Log

From (ft)	To (ft)	Thick-ness (ft)	Description
441.1	443.0	1.9	Shale, dark-gray (N3), highly carbonaceous
443.0	443.8	0.8	Coal, impure, grayish-black (N2) to black (N1); contains vitrain lenses as thick as .02 ft
443.8	445.0	1.2	Shale, medium-dark-gray (N4), moderately carbonaceous; contains moderate amounts of carbonaceous films. Contact with underlying unit abrupt
445.0	453.3	8.3	Sandstone and siltstone, interlaminated, interbedded, and bioturbated; sandstone, very fine grained, very light gray (N8); siltstone, brownish-gray (5 YR 4/1), moderately carbonaceous. Sandstone contains abundant dark opaque mineral grains, sparse mica flakes, and abundant carbon-rich laminae. Sandstone slumped in many places. Contact with underlying unit gradational
453.3	455.6	2.3	Sandstone, laminated and bioturbated, very fine grained, light-olive-gray (5 Y 6/1); root zone and burrows in basal 1.15 ft
455.6	456.6	1.0	Siltstone, brownish-black (5 YR 2/1), highly carbonaceous; contains intermixed bioturbated sandstone in upper part
456.6	458.8	2.2	Coal, black (N1), banded, vitrainous and attrital

Log

From (ft)	To (ft)	Thickness (ft)	Description
458.8	461.6	2.8	Siltstone, sandy, brownish-black (5 YR 2/1), highly carbonaceous; contains few vitrain lenses in upper part; dark-yellowish-green (10 GY 4/4) granular laminae associated with one vitrain lens. Contact with underlying unit abrupt
461.6	464.9	3.3	Sandstone and siltstone, interbedded, interlaminated, and slightly bioturbated; sandstone, very fine grained, light-gray (N7); siltstone, brownish-black (5 YR 2/1), highly carbonaceous. Contact with underlying unit abrupt
464.9	474.3	9.4	Sandstone, laminated, fine-grained, light-gray (N7); contains abundant dark opaque mineral grains and carbon-rich laminae. Base in slump contact with underlying unit
474.3	479.1	4.8	Siltstone, sandy, brownish-gray (5 YR 4/1), slightly carbonaceous; contains sparse vitrain lenses, some as thick as .02 ft and sparse carbonaceous films, moderate amounts of mica flakes in sandy parts, and intermixed bioturbated slumped sandstone in lower part
479.1	480.9	1.8	Sandstone and siltstone, interlaminated, slightly bioturbated; sandstone, very fine grained, very light gray (N8); siltstone, brownish-gray (5 YR 4/1); laminae inclined at about 10°

Log

From (ft)	To (ft)	Thickness (ft)	Description
480.9	482.3	1.4	Siltstone and sandstone, intermixed and slumped; siltstone, dark-gray (N3) and brownish-gray (5 YR 4/1); sandstone, very fine grained, light-gray (N7)
482.3	485.6	3.3	Sandstone, poorly to well laminated, fine-grained, light-gray (N7); contains abundant dark opaque mineral grains, and abundant carbon-rich laminae in lower part. Contact with underlying unit abrupt
485.6	491.0	5.4	Siltstone, massive, medium-gray (N5), grayish-orange (10 YR 7/4) in few parts; contains sparse to abundant carbonaceous films and flakes. Unit becomes sandy downward. Sandstone and siltstone intermixed through slump. Contact with underlying unit gradational
491.0	496.8	5.8	Sandstone, poorly to well laminated, fine-grained, light-gray (N7) calcareous; contains dark opaque mineral grains, sparse mica flakes, and abundant carbon-rich laminae in parts. Contact with underlying unit abrupt
496.8	501.8	5.0	Sandstone and sandy siltstone, intermixed and slumped; sandstone, very fine grained, mostly very light gray (N8), pale-yellowish brown (10 YR 6/2) in few parts; siltstone, brownish-gray (5 YR 4/1). Unit predominantly sandstone; contains sparse to moderate amounts of carbonaceous films. Contact with underlying unit gradational

Log

From (ft)	To (ft)	Thick-ness (ft)	Description
501.8	510.7	8.9	Siltstone, brownish-gray (5 YR 4/1), pale-yellowish-brown (10 YR 6/2) in one part, sandy in uppermost part; contains sparse to abundant carbonaceous films and flakes
510.7	513.8	3.1	Sandstone and silty sandstone, intermixed and slumped; sandstone fine-grained, light-gray (N7), brownish-gray (5 YR 4/1) where silty; contains sparse to abundant carbon-rich laminae and carbonaceous films and flakes
513.8	518.2	4.4	Siltstone, dark-gray N3) and grayish-black (N2) moderately to highly carbonaceous; contains sparse to abundant carbonaceous films and flakes throughout, abundant vitrain lenses in upper part, and sparse irregular sandstone bodies in lower part. Contact with underlying unit gradational
518.2	522.8	4.6	Sandstone, very fine grained to fine-grained, very light gray (N8) to light-gray (N7); contains abundant dark and light-brown opaque mineral grains, some angular siltstone fragments (rip up clasts) in one part, and a .04-ft-thick vitrain lens near base. Base in pronounced slump contact with underlying unit
522.8	524.3	1.5	Siltstone, brownish-black (5 YR 2/1/), moderately carbonaceous; contains sparse to abundant carbonaceous films

Log Continuation: Hole No.: Carbonera 1-C

 Project: Carbonera Borehole

Log

From (ft)	To (ft)	Thick-ness (ft)	Description
524.3	534.0	9.7	Sandstone and silty sandstone, poorly to well laminated fine-grained and very fine grained, light-gray (N7) to medium-gray (N5), and grayish-orange (10 YR 7/4) in few parts; contains abundant dark and light-brown opaque mineral grains, sparse to abundant carbon-rich laminae, and moderate-yellowish-brown (10 YR 5/4) siltstone in one part. Unit slighty calcareous. Base in slump contact with underying unit
534.0	542.0	8.0	Siltstone, dark-gray (N3) to brownish-black (5 YR 2/1), moderately carbonaceous; contains sparse to moderate amounts of carbonaceous films and flakes, and some bioturbated sandstone in lower part. Contact with underlying unit gradational
542.0	543.5	1.5	Shale, grayish-black (N2), highly carbonaceous; contains abundant vitrain lenses from less than .01 ft to as much as .01 ft thick. Contact with underlying unit gradational
543.5	546.1	2.6	Shale, silty and shaley siltstone, dark-gray (N3), moderately carbonaceous; contains abundant carbonaceous films and flakes, and some vitrain lenses in uppermost part

Log

From (ft)	To (ft)	Thick-ness (ft)	Description
546.1	547.3	1.2	Siltstone and silty sandstone, laminated, fine-grained to very fine grained, very light gray (N8) to medium-light-gray (N6)
547.3	551.8	4.5	Siltstone, medium-dark-gray (N4), moderately carbonaceous contains sparse carbonaceous films and flakes. Contact with underlying unit gradational
551.8	563.0	11.2	Sandstone and siltstone, interbedded, interlaminated, bioturbated and slumped; sandstone, fine-grained, mostly light-gray (N7), grayish-orange (10 YR 7/4) in few places; siltstone, brownish-gray (5 YR 4/1) to brownish-black (5 YR 2/1), moderately carbonaceous; contains sparse carbonaceous films
563.0	578.3	15.3	Siltstone and shaley siltstone, mostly medium-dark-gray (N4) and dark-gray (N3), grayish-orange (10 YR 7/4) in few parts, moderately carbonaceous; contains sparse to moderate amounts of carbonaceous films and flakes, and abundant vitrain lenses in lower part, some as thick as .02 ft

Log

From (ft)	To (ft)	Thick-ness (ft)	Description
578.3	579.1	0.8	Sandstone and siltstone, interlaminated; laminae disrupted; sandstone, very fine grained, very light gray (N8); siltstone, brownish-gray (5 YR 4/1) and dark-gray (N3), moderately carbonaceous. Sandstone contains abundant carbon-rich laminae. Contact with underlying unit gradational
579.1	580.0	0.9	Siltstone, dark-gray (N3), moderately carbonaceous; contains some intermixed sandstone, and abundant carbonaceous films and flakes
580.0	580.7	0.7	Coal, impure, black (N1) and brownish-black (5 YR 2/1); contains vitrain lenses as thick as .02 ft
580.7	581.5	0.8	Siltstone, brownish-black (5 YR 2/1) to medium-gray (N5), moderately carbonaceous; contains single vitrain lens .04 ft thick. Contact with underlying unit gradational
581.5	582.6	1.1	Sandstone, silty and sandy siltstone; sandstone, very fine grained, light-gray (N7); siltstone, light-gray (N7)
582.6	587.0	4.4	Siltstone, medium-dark-gray (N4), slightly to moderately carbonaceous; contains sparse carbonaceous films and flakes, and sparse irregular sandstone bodies in lowermost part. Contact with underlying unit gradational

Log Continuation: Hole No.: Carbonera 1-C

 Project: Carbonera Borehole

Log

From (ft)	To (ft)	Thick-ness (ft)	Description
587.0	595.3	8.3	Sandstone and siltstone, slumped, and bioturbated; sandstone, very fine grained, very light gray (N8); siltstone, medium-gray (N5) to light-brownish-gray (5 YR 6/1), moderate-yellowish-brown (10 YR 5/4) in one part; contains sparse carbonaceous films and flakes
595.3	598.9	3.6	Siltstone and minor sandstone, interlaminated, bioturbated in parts; siltstone, mostly medium-gray (N5), light-olive-gray (5 YR 5/2) in few parts, moderately carbonaceous; sandstone, very fine grained, very light gray (N8)
598.9	599.8	0.9	Siltstone, sandy, brownish-black (5 YR 2/1), highly carbonaceous; contains abundant carbonaceous films, flakes, and vitrain lenses, sparse yellowish-white bodies .003 to .006 ft long, and disseminated pyrite in one part. Vitrain lenses commonly less than .01 ft thick
599.8	602.2	2.4	Coal, black (N1), banded, vitrainous and attrital
602.2	603.4	1.2	Siltstone, grayish-black (N2) and brownish-black (5 YR 2/1) highly carbonaceous; contains abundant vitrain lenses, commonly less than .01 ft thick
603.4	603.5	0.1	Coal, impure, grayish-black (N2)

Log Continuation: Hole No.: Carbonera 1-C

 Project: Carbonera Borehole

Log

From (ft)	To (ft)	Thick-ness (ft)	Description
603.5	606.6	3.1	Siltstone, grayish-black (N2) grading downward to medium-dark-gray (N4) and brownish-gray (5 YR 4/1) highly carbonaceous in uppermost part grading downward to moderately and slightly carbonaceous; contains sparse vitrain lenses in uppermost part; lenses commonly less than .005 ft thick. Contact with underlying unit gradational
606.6	616.1	9.5	Sandstone and siltstone, bioturbated; sandstone, very fine grained, light-gray (N7); siltstone, medium-dark-gray (N4) and brownish-gray (5 YR 4/1), moderately carbonaceous. Unit contains sparse to moderate amounts of carbonaceous films and flakes, and sparse vitrain lenses
616.1	617.8	1.7	Siltstone, medium-gray (N5), moderately carbonaceous; contact with underlying unit abrupt,
617.8	622.4	4.6	Siltstone, dark-gray (N3), brownish-gray (5 YR 4/1) in one part, moderately carbonaceous; contains abundant carbonaceous films, flakes, and vitrain lenses; vitrain lenses as thick as .02 ft. Unit bioturbated; contains sandstone in basal part. Contact with underlying unit gradational

Log

From (ft)	To (ft)	Thick-ness (ft)	Description
622.4	629.5	7.1	Sandstone, Poorly to well laminted, slumped in parts; very fine grained, light-gray (N7); contains abundant dark and light-brown opaque mineral grains, and sparse to abundant carbon-rich laminae. Contact with underlying unit abrupt
629.5	629.8	0.3	Coal, black (N1), banded, vitrainous and attrital; contains vitrain lenses as thick as .04 ft
629.8	630.4	0.6	Coal, impure, brownish-black (5 YR 2/1); contains sparse vitrain lenses, some as thick as .02 ft
630.4	631.7	1.3	Shale, silty, medium-dark-gray (N4), moderately to highly carbonaceous; contains abundant carbonaceous films, flakes, and vitrain lenses; vitrain lenses as thick as .02 ft
631.7	632.4	0.7	Coal, black (N1), banded, vitrainous and attrital; contains vitrain lenses as thick as .02 ft. Cleat poorly developed, spaced .17 ft or more; white filmy mineral on cleat face
632.4	634.2	1.8	Siltstone, brownish-gray (5 YR 4/1); contains sparse vitrain lenses in uppermost part and minor bioturbated sandstone in basal part. Contact with underlying unit gradational
634.2	635.3	1.1	Sandstone and siltstone, interlaminated and bioturbated; sandstone, very fine grained, very light gray (N8); siltstone, medium-dark gray (N4), moderately carbonaceous

Log

From (ft)	To (ft)	Thick-ness (ft)	Description
635.3	637.6	2.3	Siltstone, dark-gray (N3), moderately carbonaceous
637.6	638.2	0.6	Coal, impure, black (N1), grayish-black (N2), and brownish-black (5 YR 2/1); contains vitrain lenses as thick as .01 ft
638.2	642.5	4.3	Sandstone and siltstone, interlaminated and bioturbated; sandstone, very fine grained, very light gray (N8); siltstone, medium-dark-gray (N4) to brownish-gray (5 YR 4/1), moderately carbonaceous. Unit contains abundant carbon-rich laminae and sparse vitrain lenses. Contact with underlying unit abrupt
642.5	642.7	0.2	Coal, impure, brownish-black (5 YR 2/1); contains vitrain lenses as thick as .01 ft
642.7	643.2	0.5	Coal, black (N1), banded, vitrainous and attrital; contains vitrain lenses as thick as .02 ft; cleat not apparent
643.2	644.7	1.5	Siltstone, medium-gray (N5), moderately carbonaceous; contains abundant carbonaceous films and flakes, and intermixed sandstone in basal part. Contact with underlying unit gradational

Log

From (ft)	To (ft)	Thickness (ft)	Description
			Sego Sandstone:
644.7	652.6	7.9	Sandstone and sandy siltstone, mostly bioturbated; interlaminated in few parts; sandstone, very fine grained, very light gray (N8) and light-olive-gray (5 Y 6/1); siltstone, medium-dark-gray (N4), moderate-yellowish-brown (10 YR) 5/4) in few parts, moderately carbonaceous
652.6	676.9	24.3	Sandstone, poorly to well laminated, fine-grained, light-gray (N7) to light-olive-gray (5 Y 6/1); contains abundant dark opaque mineral grains, abundant carbon-rich, silty laminae and lenses, and sparse moderate-yellowish-brown (10 YR 5/4) claystone pebbles, pods, and lenses
676.9	678.4	1.5	Siltstone and sandstone, bioturbated; siltstone, medium-dark-gray (N4) to brownish-gray (5 YR 4/1), slightly to moderately carbonaceous; sandstone, very fine grained, light-gray (N7) to light-olive-gray (5 Y 6/1). Contact with underlying unit gradational
678.4	678.7	0.3	Siltstone, medium-gray (N5), moderately carbonaceous
678.7	679.6	0.9	Sandstone, distinctly laminated, bioturbated in few parts, very fine grained, light-olive-gray (5 Y 6/1)

Log

From (ft)	To (ft)	Thickness (ft)	Description
679.6	681.3	1.7	Siltstone, sandy, and sandstone, bioturbated; siltstone, medium-gray (N5), slightly to moderately carbonaceous; sandstone, very fine grained, light-gray (N7) to light-olive gray (5 Y 6/1)
681.3	683.9	2.6	Sandstone, poorly to well laminated, mostly very fine grained, fine-grained in one part, light-gray (N7); contains abundant dark and yellowish-brown opaque mineral grains where fine grained; contains sparse carbon-rich and siltstone laminae. Abundant angular siltstone and limy bodies in one .42-ft section. Limey bodies probably fossils
683.9	684.4	0.5	Siltstone and sandstone, bioturbated; siltstone, medium-dark-gray (N4), moderately carbonaceous; sandstone, very fine grained, light-gray (N7)
684.4	687.8	3.4	Sandstone, poorly laminated, slightly bioturbated, very fine and fine-grained, light-gray (N7) to light-olive-gray (5 Y 6/1); contains abundant dark and yellowish-brown opaque mineral grains, abundant siltstone laminae, and sparse carbon-rich laminae

Log

From (ft)	To (ft)	Thick-ness (ft)	Description
687.8	692.6	4.8	Sandstone, mostly massive or poorly laminated, very fine grained, fine-grained in upper part, light-olive-gray (5 Y 6/1); contains abundant dark and yellowish-brown opaque mineral grains where fine grained, and sparse carbon-rich and siltstone laminae. Contact with underlying unit abrupt
692.6	699.0	6.4	Siltstone, sandy and sandstone, interlaminated, bioturbated in parts; siltstone, medium-dark-gray (N4) to brownish-gray (5 YR 4/1), moderately carbonaceous; sandstone, very fine grained, light-gray (N7) to light-olive-gray (5 Y 6/1). Sandstone contains abundant yellowish-brown opaque mineral grains in parts
699.0	702.3	3.3	Sandstone, massive or poorly laminated, very fine grained, light-gray (N7) to light olive-gray (5 Y 6/1)
702.3	702.5	0.2	Siltstone, medium-gray (N5) and dark-yellowish-brown (10 YR 4/2), moderately carbonaceous; contains limey bodies, probably fossils
702.5	712.9	10.4	Sandstone, massive and poorly laminated, very fine grained, grading to fine-grained downward, light-olive-gray (5 Y 6/1); contains abundant dark opaque mineral grains where fine grained, sparse siltstone lenses and pods, and sparse grayish-orange (10 YR 7/4) claystone in clustered pods and lenses

Log

From (ft)	To (ft)	Thick-ness (ft)	Description
712.9	720.3	7.4	Siltstone and sandstone, interlaminated and bioturbated; siltstone, medium-dark-gray (N4) to brownish-gray (5 YR 4/1), moderately carbonaceous; sandstone, very fine grained, light-gray (N7). Unit contains sparse grayish-orange (10 YR 7/4) claystone pods and lenses near base
720.3	732.0	11.7	Sandstone, poorly laminated, fine-grained, light-gray (N7) and medium-light-gray (N6); contains abundant dark opaque mineral grains, sparse carbon-rich laminae, and moderate amounts of moderate-yellowish-brown (10 YR 5/4) silty claystone pods, lenses, and laminae
732.0	733.3	1.3	Sandstone and silty sandstone, laminated to bioturbated, very fine grained, medium gray (N5) to light-olive-gray (5 Y 6/1); disseminated carbonaceous material associated with silty fraction
733.3	738.9	5.6	Sandstone, well to poorly laminated, bioturbated in few parts, very fine grained, medium-light-gray (N6) to light-olive-gray (5 Y 6/1); contains abundant carbon-rich laminae. Contact with underlying unit abrupt
738.9	739.4	0.5	Siltstone, sandy and sandstone, bioturbated; siltstone, brownish-gray, (5 YR 4/1) to brownish-black (5 YR 2/1), moderately to highly carbonaceous; sandstone, very fine grained, very light gray (N8). Contact with underlying unit gradational

Log Continuation: Hole No.: Carbonera 1-C

 Project: Carbonera Borehole

Log

From (ft)	To (ft)	Thickness (ft)	Description
739.4	740.4	1.0	Sandstone, poorly laminated, very fine grained, light-gray (N7)
740.4	752.4	12.0	Sandstone, silty, and sandy siltstone, bioturbated; sandstone, very fine grained, medium-gray (N5) to light-olive-gray (5 Y 6/1); siltstone, medium-gray (N5), moderately carbonaceous
752.4	762.1	9.7	Siltstone, sandy, slumped and bioturbated, medium-gray (N5) to brownish-gray (5 YR 4/1); contains sparse sandstone lenses. Unit becomes less sandy downward
762.1	763.4	1.3	Sandstone and siltstone, irregularly interbedded, disrupted, and slumped; sandstone, very fine grained, light-olive-gray (5 Y 6/1); siltstone, dark gray (N3), moderately carbonaceous
763.4	764.7	1.3	Siltstone, sandy, slumped, medium-dark-gray (N4) to brownish-gray (5 YR 4/1), moderately carbonaceous; contains several yellowish-gray (5 Y 7/2) slumped bulbous claystone bodies
764.7	769.8	5.1	Sandstone and siltstone, interlaminated and bioturbated; sandstone, very fine grained, medium-light-gray (N6) to light-olive-gray (5 Y 6/1); siltstone, medium-dark-gray (N4) to brownish-gray (5 YR 4/1), moderately carbonaceous. Sandstone contains abundant dark opaque mineral grains. Contact with underlying unit gradational

Log Continuation: Hole No.: Carbonera 1-C

 Project: Carbonera Borehole

Log

From (ft)	To (ft)	Thickness (ft)	Description
769.8	781.0	11.2	Sandstone, poorly laminated, very fine grained, mostly medium-light-gray (N6) to light-olive-gray (5 Y 6/1); contains abundant dark opaque mineral grains and abundant wispy carbonaceous siltstone laminae and lenses. Sandstone very light gray (N8) and limey in one part. Abundance of siltstone increases downward. Contact with underlying unit gradational
781.0	785.8	4.8	Siltstone and sandstone, interlaminated, slumped, and bioturbated; siltstone, medium-dark-gray (N4), moderately carbonaceous; sandstone, very fine grained, light-gray (N7) to light-olive-gray (5 Y 6/1). Contact with underlying unit abrupt
785.8	786.4	0.6	Sandstone, poorly laminated, very fine grained, medium-light-gray (N6)
786.4	786.5	0.1	Siltstone and sandstone, interlaminated; siltstone, medium-dark-gray (N4) and brownish-gray (5 YR 4/1), moderately carbonaceous; sandstone, very fine grained, light-gray (N7)
786.5	787.4	0.9	Sandstone, poorly laminated, very fine grained, light-gray (N7) to light-olive-gray (5 Y 6/1); contains abundant dark opaque mineral grains

Log

From (ft)	To (ft)	Thick-ness (ft)	Description
787.4	789.9	2.5	Siltstone and sandstone, interbedded and interlaminated, bioturbated in parts; siltstone, grayish-black (N2) and brownish-black (5 YR 2/1), highly carbonaceous; sandstone, very fine grained, light-gray (N7)
789.9	806.3	16.4	Sandstone, poorly laminated, very fine grained, light-gray (N7) to medium-light-gray (N6); contains abundant dark opaque mineral grains, and very sparse wispy medium-dark-gray (N4) and pale-yellowish-brown (10 YR 6/2) siltstone lenses and laminae becoming more abundant downward. Unit slightly bioturbated in basal part. Contact with underlying unit gradational
806.3	814.2	7.9	Sandstone and siltstone, interlaminated and bioturbated; sandstone, very fine grained, light-gray (N7) to light-olive-gray (5 Y 6/1); siltstone, medium-dark-gray (N4) and brownish-gray (5 YR 4/1), moderately carbonaceous. Unit predominantly sandstone; proportion of sandstone increases downward
814.2	814.3	0.1	Siltstone and minor interlaminated sandstone, bioturbated; siltstone, mostly grayish-black (N2) and brownish-black (5 YR 2/1), highly carbonaceous; sandstone, very fine grained, light-gray (N7). Unit contains sparse pods of pale-yellowish-brown (10 YR 6/1) claystone

Log Continuation: Hole No.: Carbonera 1-C

 Project: Carbonera Borehole

Log

From (ft)	To (ft)	Thick-ness (ft)	Description
814.3	816.7	2.4	Sandstone and minor interbedded and interlaminated siltstone and claystone, poorly laminated and slightly bioturbated; sandstone, fine-grained, medium-light-gray (N6); siltstone, dark-gray (N3), moderately carbonaceous; claystone, pale-yellowish-brown (10 YR 6/1). Claystone occurs as laminae and pods. Sandstone contains abundant dark opaque mineral grains. Contact with underlying unit abrupt, undulous
816.7	816.9	0.2	Siltstone, dark-gray (N3), moderately carbonaceous; contains minor interlaminated medium-light-gray (N6) sandstone
816.9	837.7	20.8	Sandstone, poorly laminated; fine-grained, medium-light-gray (N6); contains abundant dark opaque mineral grains, sparse dark-gray (N3) siltstone as wispy laminae and lenses, and sparse moderate-yellowish-brown (10 YR 5/4) claystone as wispy laminae, lenses, and pods
837.7	842.2	4.5	Siltstone and sandstone, interlaminated and slightly bioturbated; siltstone, dark-gray (N3) to brownish-black (5 YR 2/1), highly carbonaceous; sandstone, very fine grained, light-gray (N7) and medium-light-gray (N6). Proportion of sandstone increases downward
			End of core description; rotary drilled to 945 ft total depth; no sample returns from 842.2 to 945.0 ft