United States Department of the Interior

Geological Survey

X-ray mineralogy and lithology of the Gulf 718-1 well, U.S. Mid-Atlantic Outer Continental Shelf

by

Lawrence J. Poppe

Open-File Report 88-555

U.S. Geological Survey, Woods Hole, MA 02543

ABSTRACT

The exploratory Gulf 718-1 well was drilled to a total depth of 3905 m relative to the Kelly Bushing on the southwestern flank of the Great Stone Dome in the Baltimore Canyon Trough. X-ray diffraction and petrographic analyses show that the well penetrated a section composed of unconsolidated quartz sands and gravels (68 to 760 m); friable siltstones (760 to 1209 m); cherty micritic limestones interbedded with calcareous shales (1209 to 1460 m); calcareous siltstones and sandstones (1460 to 1977 m); micritic limestones and silty, clayey sandstones (1977 to 2260 m); silty, clayey sandstones interbedded with calcareous siltstones and cherty, zeolitic limestones (2260 to 3123 m); shale interbedded with numerous, thin coal beds and fine-grained quartz sandstones (3123 to 3414 m); and friable, micaceous sandstones interbedded with micaceous sandy, clayey siltstones (3414 to 3905 m). Glauconite is present throughout the section above 3518 m. Pyrite is common above 3170 m in the very dark gray to black shales and fine-grained sandstones; disordered cristobalite and phosphorite are usually associated with the limestones. Low-magnesian calcite is the predominate cement throughout the section; minor amounts of chert, siderite, hematite, goethite, and dolomite are occasionally observed.

INTRODUCTION

The Gulf 718-1 well was drilled in 58 m of water between January 19 and April 31, 1979, to examine the petroleum potential of the southwestern flank of the Great Stone Dome (Fig. 1). The well site was located in the Baltimore Canyon Trough on the U.S. Atlantic Outer Continental Shelf about 102 km east southeast of Atlantic City, N.J. at latitude 39° 15.657' N and longitude 73° 9.957' W. Drilling was conducted from the Diamond M Company semisubmersible rig New Era. Drilling operations continued to a total depth of 3905 m relative to the Kelly bushing (RKB), a total penetration depth equivalent to 3825 m of section below the sediment/water interface. The well, which was classified as a dry hole, was plugged and abandoned after testing.

All depth references in this report for the lithologic descriptions or the X-ray diffraction data are based on depths RKB. The distance below the sediment/water interface for any given sample may be calculated by subtracting 80 m (the sum of the 58 m water depth and the 22 m distance between sea level and the Kelly Bushing) from the depth RKB. Drill cutting samples were hand-picked to separate sufficient amounts of each different lithology for description and analysis. The subsamples were subsequently sonified and washed in the laboratory to prevent contamination by drilling fluids. Because of this washing procedure and because of winnowing and abrasive processes associated with the circulation of drilling mud, some of the natural silts and clays have probably been removed from the less lithified sediments. Furthermore, because coarse sand and gravel tend to disaggregate into their individual constituent grains during drilling, and because of other operational factors such as caving that are associated with drilling, drill-cutting samples may sometimes misrepresent the actual material penetrated in a given interval and emphasize the more consolidated, fine-grained units. Therefore, the analysis and description of rotary drill cuttings are supplemented by electric logs and descriptions of sidewall cores. The logs and cores, when used in conjunction with the cuttings, helped delineate the lithologic variations within any given depth interval.

METHODS

The lithologic descriptions were performed on 352 samples taken at 9.14-m intervals between 162 to 2887 m and at 3.05-m intervals between 2887 to 3895 m RKB. No intervals were sampled above 162 m or below 3895 m. X-ray powder diffraction analyses were performed on 137 of the cutting samples from 78 levels in the well. A split from each sample was mounted and X-rayed as a randomly oriented powder. The clay fraction from each sample was separated by centrifuge and mounted as an oriented

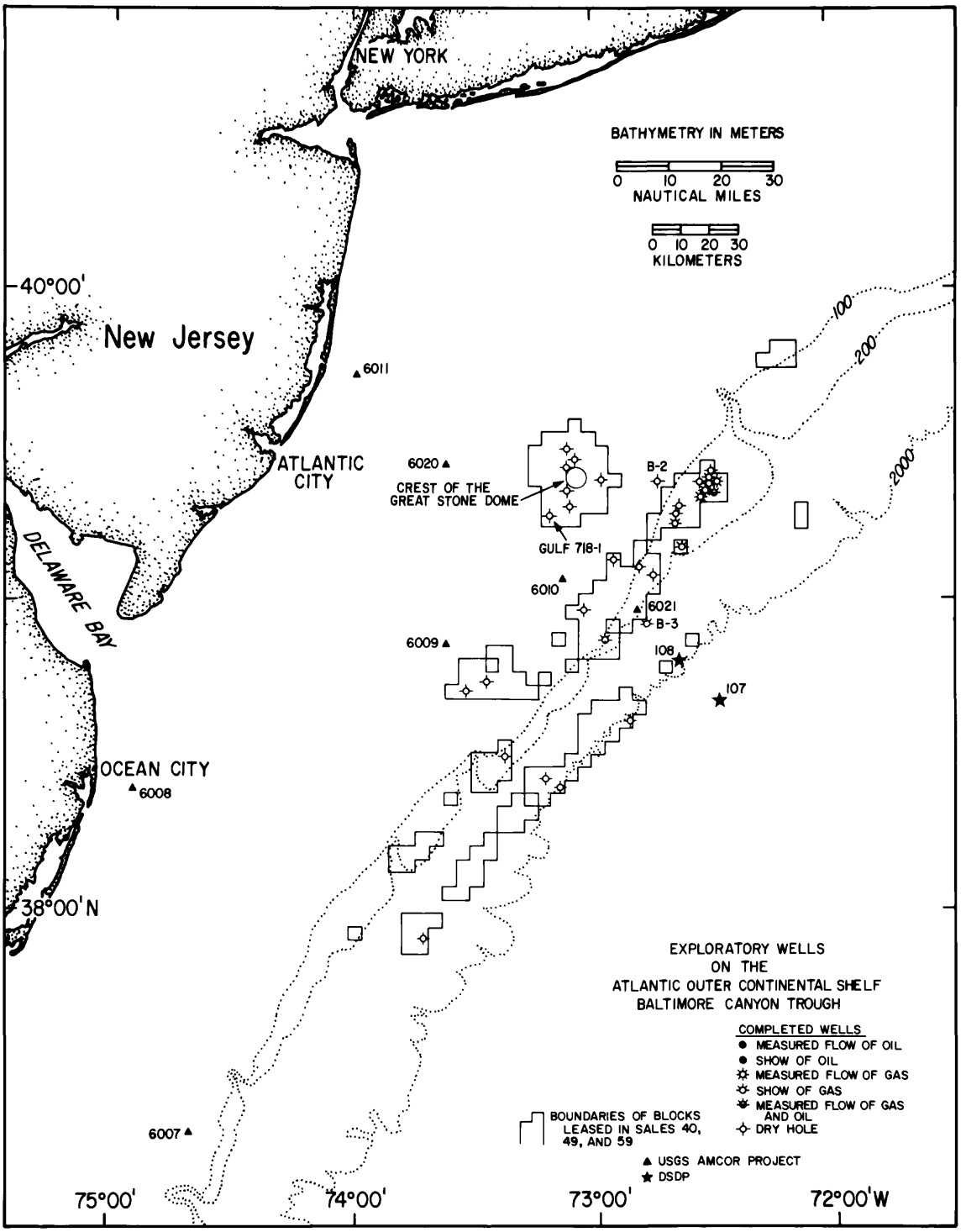

Figure 1. Map showing the distribution of wells drilled in the Baltimore Canyon Trough, Mid-Atlantic Outer Continental Shelf. The location of the Great Stone Dome, lease block boundaries, and drilling results are also plotted on the map.

aggregate on a silver filter. Each oriented clay mineral sample was subjected to four treatments to determine which clay minerals were present: air drying, glycolation with ethylene glycol, heating to 400 °C, and heating to 550 °C. The data from the randomly oriented and oriented aggregate mounts were combined, and semiquantitative estimates of the minerals present were made by comparing the sample diffraction peak intensities with the intensities recorded from a collection of external standards. Clay mineral abundances were estimated by a method described by Biscaye (1965). The semiquantitative estimates are reported in relative weight percentages of crystalline material and are generally considered to be accurate to within 10 percent of their actual values; however, even if due only to rounding errors, the lower values (<10 percent) may vary considerably more than this.

A split was taken from each sample and mounted in Piccolite (N=1.52) as a smear slide. These slides were used to check the semiquantitative diffraction results, to generate the textural descriptions, to correct the data for layered silicates occuring in the silt fraction, to detect amorphous phases or those occuring in trace amounts, and to examine the biogenic debris.

The electric log and sidewall core information for the Gulf 718-1 well is on file at the USGS office in Woods Hole, Mass. Copies are available from the National Geophysical Data Center, Boulder, Co. Rotary drill cuttings are the property of Gulf Oil Corporation, who made them available to the USGS.

LITHOLOGY

The stratigraphic section penetrated by the Gulf 718-1 well encountered middle neritic to nonmarine depositional environments that ranged in age from Pleistocene to Lower Cretaceous (Poppe and others, 1987). Based on detailed lithologic descriptions (Appendix 1), this sedimentary column may be divided into eight major lithologic units. Unit I, from the sediment/water interface down to 760 m, is composed mostly of unconsolidated sands and gravels with occasional layers of stiff clayey silt. Unit II, between 760 and 1209 m, consists primarily of stiff to friable, grayish-brown, sandy, clayey siltstones. Unit III, between 1209 and 1460 m, is composed mainly of light gray, cherty, micritic limestones interbedded with calcareous shales and two argillaceous dolostones. Unit IV, between 1460 and 1977 m, consists mainly of gray, calcareous, clayey siltstones and gray, silty, clayey sandstones interbedded with thin, cherty, micritic limestone beds. Unit V, between 1977 and 2260 m, consists primarily of gray to dark gray, micritic limestones and light gray, silty, clayey sandstones. Unit VI, between 2260 and 3123 m, is composed mainly of light brownish gray, silty, clayey sandstones interbedded with a gray calcareous siltstone and a cherty, zeolitic limestone. Unit VII, between 3123 and 3414 m, contains a light brownish gray to dark gray shale interbedded with numerous thin coal/lignite beds and fine-grained quartz sandstones. Unit VIII, between 3414 and 3905 m, is composed primarily of light brownish gray to gray, friable, micaceous sandstones interbedded with dark gray to very dark gray, micaceous, sandy, clayey siltstones.

The detailed lithologic log (Appendix 1) permits the determination of depth- and age-related variations in the relative abundances of the common rock types such as sandstone, siltstone, shale, carbonate, and coal. Athough carbonates certainly make up a major portion of the section, especially between 1213 and 1460 m and 1993 and 2259 m, sandstones and siltstones are the dominant lithologies (Table 1). Coal, important both as an indicator of depositional environment and because of its sensitivity to diagenetic changes resulting from pressure and temperature, is a major volumetric component of the stratigraphic column only in the interval between 3200 and 3415 m.

X-RAY MINERALOGY

Layered silicates, which ranged in concentration from 1 to 79 weight percent of the samples, are a major constituent of the well sediments (Table 2). Smectite, probably montmorillonite, is usually the most abundant clay mineral in samples below 1131 m and above 2400 m and in limestones thoughout

Table 1. Grouping of rock types encountered in the Gulf 718-1 well. The values are presented in relative percent by volume and show the siliciclastic nature of the section. Age determinations (Poppe and others, 1987) show that carbonate regimes occur in the upper part of the Albian, Cenomanian, upper part of the Maestrichtian, and lower portion of the Paleogene sections. Coal is common only in the Hauterivian/Valanginian through Aptian portion of the section.

INTERVAL		PERCENT SAND, GRAVEL, AND SANDSTONE	PERCENT CLAY, SHALE, SILTSTONE, AND CLAYSTONE	PERCENT LIMESTONE AND DOLOMITE	PERCENT COAL AND LIGNITE
FEET	METERS				
530-1000	162-305	100.0	0.0	0.0	0.0
1000-2000	305-610	90.1	9.9	0.0	0.0
2000-3000	610-914	57.9	42.1	0.0	0.0
3000-4000	914-1219	3.2	95.3	1.5	0.0
4000-5000	1219-1524	7.5	56.7	35.8	0.0
5000-6000	1524-1829	44.5	53.4	1.2	0.9
6000-7000	1829-2134	21.8	53.1	25.1	0.0
7000-8000	2134-2438	45.1	33.5	19.6	1.8
8000-9000	2438-2743	70.7	28.4	0.9	0.0
9000-10000	2743-3048	63.4	33.5	2.1	1.0
10000-11000	3048-3353	38.1	40.0	0.7	21.2
11000-12000	3353-3658	42.0	48.8	1.1	8.1
12000-12813	3658-3906	51.8	48.1	0.0	0.1

Table 2. Estimated mineral modes, in relative weight percent, determined from x-ray powder diffraction and smear slides for drill cuttings from the Gulf 718-1 well. SMC: smectites; C-S: mixed layer chlorite smectite; I-S: mixed layer illite smectite; CHL: chlorite; I/M: illite and/or mica; KAO: kaolinite; GLA: glauconite; QTZ: quartz; DC: disordered cristobalite; FLD: feldspar; CAL: calcite; ARA: aragonite; D/A: dolomite/ankerite; SID: siderite; HEM: hematite; GOE: goethite; PYR: pyrite; APA: apatite; AMP: amphiboles; ZEO: zeolites; A/G: anhydrite/gypsum; HAL: halite. G: gray; DG: dark gray; LG: light gray; BG: brownish gray; BR: brown; BK: black; W: white. A blank indicates that the mineral was not detected; T = trace; sample depths are in meters.

SAMPLE DEPTH	SMC	C-S	I-S	CHL	I/M	KAO	GLA	QTZ	DC	FLD	CAL	ARA	D/A	SID	HEM	GOE	PYR	APA	AMP	ZEO	COMMENTS
171-180				1	1		5	71		17	4		T				T		T		washed silty sand
226-235				2	5		1	85		6							T				washed sand
271-280				2	5		T	83		8	T								T		washed sand
299-308				2	4		T	76		15	1						T				washed sand
390-399					T			68		4	11			5			11				washed gravel, shell hash
445-454				T	2			60		2	6		22	2			4	T			washed gravel, D/A fragments
500-509		T	T	3	6	5	T	48		2	T		23	T			11				silty sand, D/A fragments
555-564			T	5	11	4	13	49		2			6	2			6				silty sand
610-619							6	77		2	6			3			6				washed gravel
664-674							6	83		1	T		6	1			3				washed gravel
728-738			T	1	2	T	T	65		4	T		T	6			20				washed sand
783-793			2	8	7	9		16		2	1			52			3				DG siltstone
783-793			T	4	3	7		19		2				63	1						BR nodule
838-847			T	T	1	1	T	23		1	T		T	4			68				DG iron-rich siltstone
893-902	T		2	6	12	10	T	43		5	1		6	T			13		T		DG silty sandstone
893-902	T	T	T	8	10	16	T	33		5	3		T	12			10				G silty clayey sandstone
948-957			4	5	10	11	T	36		4	13		10	1			6				DG silty sandstone
948-957	T		3	10	14	13	T	20		3	21		T	4			11	T	T		G calcareous siltstone
1003-1012	1		5	10	12	11	T	27		4	22		2				5				G diatomaceous shale
1067-1076	7		1	3	5	6	5	14	14	2	25		6	T			5	3		3	DG cherty siltstone
1067-1076	5		1	3	6	6	4	10	10	2	15		23				6	5		4	G cherty calcareous siltstone
1131-1140	8		T	1	6	4	6	11	26	2	24						9	2		T	DG cherty calcareous siltstone
1131-1140	11		T	2	5	4	5	19	19	2	17		10				5	T	T	T	G cherty calcareous siltstone
1186-1195	16		1	3	3	4	T	19	13	2	26		T	2			6	T		3	DG siltstone, volc. glass
1186-1195	6		4	5	7	8	T	13		2	33		6	2			5			8	LG siltstone, volc. glass
1262-1271	13	T	T	2	3	2	T	7	10	T	38		15				8				DG cherty limestone
1262-1271	11		1		T	T	T	2			79						5	T			G micritic limestone
1317-1326	7		1					T	20		71										LG cherty micritic limestone
1317-1326	11		1			1		3	T		75							8			W micritic limestone
1371-1381	9	T	T	T	1	T	T	4	7		41						T	2		33	G limestone
1371-1381	7		T		1		T	T	27	T	59						T			3	LG cherty limestone
1371-1381	5		2		1		T	T	28		59						T	2		2	W cherty limestone
1427-1436	6		3	T	3	T	T	3			72			1				8		3	G limestone
1427-1436	16	1	T	T	2	T	T	12			67	T	T								LG limestone
1472-1481	16		T	10	9	8	T	18		3	29			T			2	4			calcareous siltstone

SAMPLE DEPTH	SMC	C-S	I-S	CHL	I/M	KAO	GLA	QTZ	DC	FLD	CAL	ARA	D/A	SID	HEM	GOE	PYR	APA	AMP	ZEO	COMMENTS
1472-1481	24		T	T	3	T	T	7	16		47						T	T		T	LG limestone
1509-1518	16		2	6	10	15	T	16		4	20			T			4	7			G calcareous siltstone
1509-1518	27		T	T	4	T	T	12			55						T	T			LG limestone
1545-1554	20		T	4	5	10		9		2	33						T	4			calcareous siltstone
1545-1554	22		T	T	2	1	T	13	16	T	42						T	2			LG limestone
1582-1591	19	T	2	3	5	5	T	22		5	33			T			1	3			G calcareous siltstone
1582-1591	10		T	T	1	T	3	7	18	T	55			T						4	LG cherty limestone
1619-1628	16		1	6	5	7	T	16		6	34			T			2	6			DG calcareous siltstone
1619-1628	14	T	T	T	1	T	T	11		2	52						2			15	LG limestone
1655-1664	15		T	2	5	11	1	19	13		22			T			T			10	G calcareous sandstone
1655-1664	15		1	3	5	4	T	5	17	T	37						T	4		12	LG cherty limestone
1692-1701	9		T	6	9	8		45		2	8			11	T		1				BG sandstone
1692-1701	7		1	2	3	5	T	10		1	30			T			31			10	pyrite-rich siltstone
1692-1701	18		2		2			16	T	6	54		T					T		T	W limestone
1765-1774	4		1	5	7	6		31		2	37		T	T			6				G calcareous sandstone
1765-1774	6		2	1	3	1		29		1	43		T	T			3	10		T	LG sandy limestone
1862-1871	8	T	T	4	5	5	T	9		4	58			3			3				G limestone
1862-1871	16	T	T	T	1	T	T	7	8		57						T	T		8	LG cherty limestone
1899-1908	1		T	1	1	1	T	7			5			81			1				siderite nodule
1899-1908	16		T	T	3	T	T	7	T		69									10	LG limestone
1945-1954	2	T	T	5	7	7	T	10		2	64						1				G limestone
1981-1990	T		2	7	7	16	T	23		6	34		T					4			silty calcareous sandstone
2018-2027	T		1	5	6	17	T	13		4	49		T	2			1				DG limestone
2018-2027	16		T		2		T	10	12		46						T			12	LG cherty limestone
2091-2100	16		1	9	9	14	T	20		3	23	T		1			2	T		T	G calcareous siltstone
2091-2100	15		1	5	3	4	T	16	2	T	52	2		T			T			T	LG limestone
2164-2173			T	6	4	12	T	9		5	48		T	6			8				DG limestone
2164-2173	11	T	1	T	T	T	T	8	5		72	T									LG limestone
2201-2210			T	5	4	12	1	8		2	46			4			2	16			G limestone
2201-2210	17		T	T	2	T		5		T	66							T		8	LG limestone
2201-2210	5			T	T	T		9	14		70										W cherty micritic limestone
2249-2256	T	1	1	7	5	13	T	18		4	48			T			1				G sandy limestone
2292-2302		1	T	6	7	25	T	21		5	26		T	1			6	T			G siltstone
2292-2302	10		T	T	T	T	T	6	7	T	60							2		12	LG limestone
2347-2356	10	1	3	7	6	8	T	12		2	26			4			5			15	G siltstone

SAMPLE DEPTH	SMC	C-S	I-S	CHL	I/M	KAO	GLA	QTZ	DC	FLD	CAL	ARA	D/A	SID	HEM	GOE	PYR	APA	AMP	ZEO	COMMENTS
2347-2356	17	T	T	T	T	T	1	7	11		51		T				T			10	LG cherty limestone
2384-2393		2	T	4	6	39		43		3	T		T	1							DG sandstone
2384-2393	16		T	T	2	T	T	6	16	T	58		T							T	LG cherty limestone
2384-2393			T	T	T	10		11			T			77	T						BR ironstone
2429-2432	T	3	T	12	4	51	T	13		2	4			3			6				BK siltstone
2521-2530	T	T	2	11	8	36	T	21		4	5		T	4			8				DG siltstone
2521-2530			T	3	2	12	T	44		4	29		T	4							calcareous sandstone
2576-2585	T	T	1	12	18	40	T	14		4	T			2			4	3			DG siltstone
2576-2585			T	1	1	3	T	26		5	62						T	T			sandy limestone
2631-2640	T		2	6	32	28	1	21		2	1			1			T	6			dark micaceous siltstone
2676-2685	T	T	1	3	36	21	T	19		3	6			1			3	6			dark micaceous siltstone
2676-2685			T		T	T					98										micritic limestone
2676-2685					T	T		T								T	11	88			phosphorite nodule
2795-2804		T	T	2	30	20	T	31		3	6			2			4				DG micaceous siltstone
2795-2804			T	2	11	9	T	55		3	13		3	3							LG sandstone
2847-2850	9		T	1	5	9	T	24	T	3	31			T			T	3		12	calcareous siltstone
2920-2923	T		1	9	14	32	T	23		5	5		T	4			6	T			DG siltstone
2920-2923	22		T		5	1	T	7	2	T	49		1	T			T	1		11	LG sandy limestone
2954-2957		T	1	9	20	37	T	19		5	4			1			1	T			DG siltstone
2954-2957	10		T		1	T	T	T	28		56							3			cherty micritic limestone
2987-2990			1	5	14	31	T	28		4	5		2	2			8				DG siltstone
3060-3063		T	1	5	19	30	1	23		4	8			2			6	T			DG siltstone
3094-3097	23	T	T	T	4	1	1	7	7	T	41		T	T			T			13	G cherty sandy limestone
3143-3146	18			T	4	T	T	6	14		47			T			T	2		7	LG cherty limestone
3167-3170			T	4	14	45	T	25		4	10			2			3				DG siltstone
3216-3219			1	3	38	25	T	22		5	1		T	2			1	1			DG micaceous siltstone
3216-3219	18	T	T	T	4	2	T	14	10	T	30		2					3		14	LG cherty limestone
3246-3249	2		T		3	9	T	33		10	24	4	2	7			T				LG silty sandstone
3283-3286	14		T	T	2	7	T	33		4	29	T		5			T			4	LG sandstone
3313-3316	10			T	2	7	1	34		6	34	T	T	2						3	LG sandstone
3356-3359		1	2	8	33	35	T	13		5	T		T	T			T	T			BK micaceous siltstone
3356-3359	T		T	2	13	12	T	39		3	4			5	T		T				sandstone, A/G: 5, HAL: 15
3371-3374		3	T	6	25	40	T	18		5	T		T	1			T				DG siltstone
3386-3389		2	2	5	21	40		18		6	4			2							DG siltstone
3386-3389	18		T	2	6	12	T	16	6	4	29			2			T	T		4	LG cherty calcareous siltstone

SAMPLE DEPTH	SMC	C-S	I-S	CHL	I/M	KAO	GLA	QTZ	DC	FLD	CAL	ARA	D/A	SID	HEM	GOE	PYR	APA	AMP	ZEO	COMMENTS
3420-3423		1	1	3	43	25	1	14		6	T			T			T	4		T	DG micaceous siltstone
3420-3423	24			T	4	8	T	12	11	4	29		T	1						6	LG cherty calcareous siltstone
3453-3457		1	2	6	19	32	T	29		6	T		T	3			T				BK sandy silt
3453-3457	11		1	T	1	3	T	13	13	7	42			2						7	LG cherty limestone
3484-3487		T	1	8	35	18	T	23		8	T			4		T	T				BK micaceous siltstone
3518-3521			2	6	29	20	T	26		10	2		T	2							BK micaceous siltstone
3518-3521	12		T		1	T	T	3	11	T	44		T					22		4	LG cherty limestone
3518-3521			T	T	2	1		29		12	54			T			T				LG sandy limestone
3548-3551		T	4	9	17	29	T	25		10	T		T	4							BK siltstone
3548-3551			T	6	5	9		37		11	26			5			T				LG calcareous sandstone
3578-3582		T	2	5	36	19	T	23		8	T		T	4							BK micaceous siltstone
3578-3582	T		T	1	4	3		55		11	19	T	T	4						T	LG sandstone
3609-3612		T	T	6	49	11		25		6				2							BK micaceous siltstone
3609-3612		T	T	3	9	6		50		11	18			T							LG mic. sandstone, HAL: T, A/G: T
3639-3642	T	1	1	8	33	27		20		6	T			2							BK micaceous siltstone
3639-3642	4	T	T	4	3	2		26		8	40			T						9	LG sandy limestone
3670-3673	T	2	1	5	41	15	T	22		10	T			2				T			DG micaceous siltstone
3700-3703		T	T	4	40	18		25		10	T			2							DG micaceous siltstone
3700-3703		T	T	2	24	10		35		10	17			T			T				LG calcareous sandstone
3719-3722	T	T	T	5	43	18		24		8				T			T			T	DG micaceous siltstone
3752-3755		T	T	3	51	11		26		7	T			5							DG micaceous siltstone
3752-3755		T	T	1	10	2		70		12	2			T			T				LG micaceous sandstone
3786-3789		1	2	9	41	13		23		8	T			2			T				DG micaceous siltstone
3786-3789		T	T	1	4	2		55		24	11		T	2							LG micaceous sandstone
3828-3831		1	3	4	39	13		27		9	T			2			T				DG micaceous siltstone
3828-3831	T		T	1	8	3		55		15	13		T	3							LG micaceous sandstone
3856-3859			2	7	42	9		27		10				2			T	T			DG micaceous siltstone
3856-3859			T	3	10	5		44		20	9		T	8			T				LG sandstone
3856-3859				T	T	T		98			T										clear authigenic crystals
3892-3895		2	4	3	45	16		17		6	T		T	1			T	3			DG micaceous siltstone
3892-3895			T	2	12	9		49		9	11		2	2			T	3	T		LG sandstone

the well. Kaolinite, which usually forms during severe chemical weathering under nonalkaline conditions, is the dominant clay mineral in the noncalcareous sandstones, siltstones, and shales below 2400 m and is also an major component in the overlying portion of the section. Most of the chlorite and a significant portion of the illite/mica occurs as silt to medium sand-sized flakes rather than in the clay fraction and, therefore, tends to mask the true relative abundances of the clay minerals reported in Table 2. This effect is most apparent in the upper washed portion of the section (<738 m) and in the micaceous siltstones and sandstones below 2676 m. Although traces of mixed-layer illite-smectite occur throughout the well, this mineral is more common in the Tertiary portion of the section. Mixed-layer chlorite-smectite is rare in the Tertiary strata, but becomes a minor constituent in the Cretaceous.

Quartz was detected in the X-ray diffraction patterns and smear slides from almost every well sample; it ranges in size from gravel to fine silt. The strata above 308 m and below 3818 m are composed mainly of subarkosic sandstones. Potassium feldspar dominates above 783 m; sodium and calcium plagioclase is generally much more common in the remainder of the well. The absence of evidence for feldspar alteration by kaolinization, sericitization, or vacuolization above 2400 m and only trace amounts below this depth suggests that these variations are mainly due to changes in provinance. Inasmuch as the quartz and feldspar grains are generally subrounded and because these minerals tend to occur together, they are probably detrital in origin.

Low-magnesium calcite along with minor amounts of siderite and trace amounts of aragonite and euhedral rhombs of dolomite are common throughout the section. The limestones are typically micritic, but contain locally significant microfossil and nannofossil components. Although calcite is the primary cementing agent in the well, siderite is occasionally important as a secondary cement, as evidenced by nodules and ironstones.

Lithic fragments occur in sandstones throughout much of the section but never comprise a major rock-forming component. Reported rock fragments include shale, chert, schist, and volcanic glass grains.

Glauconite, which exists in trace amounts throughout much of the well, occurs mostly in its pelletal rather than vermicular form and is concentrated in portions of the Miocene (555 to 674 m) and Oligocene (1067 to 1140 m) sections. The presence of this mineral, which is suggestive of marine depositional environments, is noticably depleted or absent below 3518 m in the well.

The disordered cristobalite, or opal-CT, is usually associated with micritic limestones and constitutes up to 28 weight percent of these samples. This disordered cristobalite is a common marine silica phase and occurs here in the form of silt-sized lepispheres and as detrital rock fragments of chert.

Pyrite is common in the section above 3170 m, with some intervals being very pyritic. Below 3170 m, pyrite occurs only in scattered trace amounts. The pyrite enriched levels are generally restricted to black, very dark gray, and gray siltstones and sandstones. The pyrite occurs chiefly as framboidal spheres, but it also fills the tests of foraminifera. It is occasionally found as medium sand-sized to very coarse, silt-sized shiny octahedral euhedrons. The pyrite has been altered to goethite and hematite at a few locations in the well.

Phosphorite, probably calcium fluorapatite, is present throughout much of the well but is mainly concentrated in the limestones. The phosphorite, which typically occurs in the form of coarse silt- to fine sand-sized grains, was found at 2680 m in subrounded nodular clasts as much as .5 cm in diameter. X-ray diffraction patterns indicate moderately well crystallized material, although microscopic examination reveals aggregates of cryptocrystalline texture usually observed in marine phosphorites.

Clinoptilolite was detected in many of the carbonate-rich samples. This zeolite occurs as silt-sized, lath-shaped grains. The presence of smectite and clinoptilolite indicates a volcanic parent material component, and volcanic glass shards were reported at five locations in the well. However, the absence of basic igneous rocks elsewhere in the well suggests that either all of the remaining volcanic ash has been diagenetically converted or that biogenic silica is probably a primary source of silica in these

minerals and in the detected disordered cristobalite. The absence or depletion of diatoms and other siliceous bigenic debris throughout much of the well suggests the diagenetic dissolution of biogenic amorphous silica.

Gypsum, anhydrite, and halite were detected in two intervals within the well; 3356 to 3359 m and 3609 to 3612 m. These minerals typically form under evaporitic conditions and suggest the presence of lagoonal or supratidal depositional environments.

REFERENCES

Biscaye, P.E.,1965, Mineralogy and sedimentation of Recent deep-sea clay in the Atlantic Ocean and adjacent seas and oceans: Geological Society America Bulletin, v. 76, no. 7, p. 803-832.

Poppe, L.J., Hall, R.E., Cousminer, H.L., and R.W. Stanton, 1987, Lithology and biostratigraphy of the Gulf Oil 718-1 well, U.S. Mid-Atlantic Outer Continental Shelf (abs): Geological Society America, Abstracts with Programs, v. 19, no. 2, p. 124.

APPENDIX 1

Lithologic descriptions of rotary drill cuttings and sidewall cores from the Gulf Oil 718-1 well in the Baltimore Canyon Trough. All sample depth intervals are in meters relative to the Kelly Bushing.

162-171 Sand and gravel, mostly quartz, washed

171-180 Sand, median grain size 1.5-2.5 phi, poorly sorted, subangular, washed, mostly quartz, some gravel (1%), shell hash (5%), glauconite (5%), and mica (3% muscovite), and traces of brown hornblende and garnet

180-189 Medium sand, mostly quartz, glauconitic

189-198 Medium sand, mostly quartz, washed, glauconitic

198-207 Fine sand, mostly quartz, washed

207-216 Medium sand, mostly quartz, washed

216-226 Sand, quartz with shell hash

226-235 Sand, median grain size 1.5 phi, well sorted, subangular-subrounded, washed, mostly quartz, some mica (muscovite, chlorite, and biotite), and framboidal pyrite, traces of glauconite and zircon

235-244 Medium sand, mostly quartz, washed

244-253 Coarse sand, mostly quartz, washed

253-262 Medium sand, iron-stained

262-271 Coarse sand quartz with shell hash, washed

271-280 Sand, median grain size 1.0-2.0 phi, poorly sorted, subangular, washed, mostly quartz, some mica (medium sand-sized muscovite, chlorite, and a trace of biotite), traces of green hornblende, framboidal pyrite, glauconite, and kyanite

280-290 Sand, clayey, with shell hash

290-299 Medium sand, quartz, glauconitic, washed

299-308 Sand, median grain size 2.0-3.0 phi, poorly sorted, subrounded, washed, mostly quartz, some iron-stained grains, shell hash (15%), and mica (5% muscovite, biotite, and chlorite), and traces of zircon, green hornblende, and framboidal pyrite

354-363 Coarse sand, quartz, washed, shell hash

381-390 Medium sand, shell hash

390-399 Sand, median grain size 0.5 phi, angular-subangular, well sorted, mostly quartz, some mollusk shell hash (10%)

399-408 Coarse sand and gravel, shell hash

408-418 Coarse sand and gravel, shell hash

418-427 Gravel, silicates and shell hash, washed

427-436 Gravel, silicates and shell hash, washed

436-445 Gravel, silicates and shell hash, washed

445-454 Gravel and coarse sand, shell hash, washed

454-463 Gravel, median grain size -1 phi, moderately sorted, subrounded, washed, mostly rock fragments, some coarse and medium sand, gray shale chips (2%), gastropod fragments (5%), and a trace of phosphorized shell fragments

463-472 Gravel, silicates and shell hash, washed

472-482 Gravel, sandy, clayey

482-491 Gravel, quartz and rock fragments, washed

491-500 Coarse sand and gravel, quartz and rock fragments, washed

500-509 Gravel, median grain size 1.0 phi, poorly sorted, subrounded, some shell hash, partially washed, mostly quartz, minor lithologies are a dolostone and a gray sandy siltstone with some framboidal pyrite and traces of tourmaline, glauconite, and zircon

509-518 Silt, sandy, clayey, shell hash

518-527 Silt, sandy, clayey, shell hash

527-536 Silt, sandy, clayey

536-546 Medium sand, silty, clayey

546-555 Silt, sandy, clayey

555-564 Sand, median grain size 0 phi, poorly sorted, subangular-subrounded, some shell hash and framboidal pyrite, mostly quartz, partially washed, some euhedral and framboidal pyrite, sponge spicules, and diatoms, minor lithologies include a reddish brown iron-stained shale (1%), a reddish brown iron-stained sandstone (1%), and a gray, slightly micaceous siltstone (5%)

564-573 Gravel, quartz and rock fragments, washed

573-582 Gravel, some calcareous quartz sandstone

582-591 Gravel, some calcareous quartz sandstone, shell and bryozoan hash

591-600 Gravel, some calcareous quartz sandstone

600-610 Coarse sand and gravel, shell hash

610-619 Gravel, median grain size 0 phi, moderately sorted, subrounded, washed, mostly coarse sand-sized rock fragments, some sandstone with a white carbonate matrix (5%), shale fragments (1%), shell hash (3%), and mica (1% muscovite)

619-628 Coarse sand and gravel, shell hash

628-637 Gravel, quartz and rock fragments, washed

637-646 Sand and gray and reddish iron-stained siltstones

646-655 Gravel, sandy, silty

655-664 Medium sand, washed

664-674 Sand, median grain size 0.0 phi, very well sorted, subangular, mostly quartz, washed, some shell hash (5%), glauconite (5%), and sand-sized muscovite flakes, minor lithologies include a very light gray, calcareous sandstone with medium sand-sized quartz grains and a gray siltstone

674-683 Coarse sand, washed

692-701 Coarse sand and gravel

701-710 Sand, silty

710-719 Coarse sand and gravel

719-728 Medium sand, washed

728-738 Gravel, sandy, median grain size 0.0 phi, poorly sorted, subangular, mostly quartz, washed, siderite coatings, some coarse sand-sized muscovite flakes and pyrite, traces of calcareous nannofossils, chlorite, glauconite, and sponge spicules, minor lithologies include an iron-stained sandstone and a brownish gray siltstone

737-746 Sand, silty, clayey

746-756 Coarse sand, washed

756-765 Silt, sandy, partially washed, some shell hash (1%) and mica flakes (2% muscovite and biotite)

765-774 Sand, silty, gravelly, washed

783-792 Gravel, sandy, median grain size 0.0 phi, poorly sorted, subrounded, partially washed, mostly quartz with some metamorphic rock fragments, some sand-sized muscovite and pyrite, minor lithologies include a brownish gray, siderite-bearing sandstone and a white quartz sandstone with a calcareous matrix

792-802 Siltstone, sandy, clayey, some lignite

802-811 Siltstone, sandy, clayey

811-820 Siltstone, sandy, clayey, reddish brown iron-staining

820-829 Siltstone, sandy, clayey

829-838 Siltstone, sandy, clayey, grayish brown

838-847 Siltstone, sandy, clayey, grayish brown (2.5Y 5/2), some mica (muscovite 10% and chlorite 5%), glauconite (1%), and framboidal pyrite (5%), traces of zircon, sponge spicules, and polished chert fragments

847-856 Siltstone, sandy, clayey, reddish brown and a silty clayey sandstone

856-866 Sand, silty, clayey, slightly micaceous

866-875 Sandstone, very fine grained, reddish brown and a gray siltstone

875-884 Siltstone, sandy, clayey, gray and a reddish brown fine grained sandstone

884-893 Siltstone, sandy, clayey, gray

893-902 Siltstone, sandy, clayey, grayish brown (2.5Y 5/2), friable, slightly micaceous, poorly-cemented, some mollusk shell hash and framboidal pyrite, clay matrix about 35%, minor lithology is a medium grained sand

902-911 Siltstone, sandy, clayey, gray

911-921 Sand, median grain size 0-1.0 phi, poorly sorted, subrounded, silty, some mica (1% muscovite), shell hash (5%), minor lithology is a very dark gray (10YR 3/1) shale

921-930 Siltstone, sandy, clayey, gray, slightly micaceous and a coarse sandstone

930-939 Siltstone, sand, clayey, gray and a medium grained sandstone

939-947 Siltstone, sandy, clayey, dark gray to gray

947-957 Siltstone, sandy, clayey, gray (5Y 5/1), some muscovite and chlorite, framboidal pyrite, shell hash, and dolomite rhombs, poorly-cemented, friable, clay matrix about 30%, minor lithologies include a chert and a sandy limestone

957-966 Siltstone, sandy, clayey, gray, and a chert

966-975 Siltstones, dark gray to light gray

975-985 Siltstones,dark gray to light gray

985-994 Shale, gray with some shell hash

994-1003 Shale gray, slightly micaceous

1003-1012 Shale, gray (5Y 5/1), some muscovite, shell hash (10%), framboidal pyrite, dolomite rhombs, and diatoms (40%), traces of glauconite, sponge spicules, calcareous nannofossils, and foraminifera fragments, clay matrix about 45%, minor lithology is a coarse quartz sand

1012-1121 Shale, gray, slightly micaceous

1121-1130 Shale, gray and a quartz sandstone

1130-1139 Shale, gray

1139-1149 Siltstone, sandy, clayey, dark gray to gray

1149-1057 Siltstone, sandy, clayey, dark gray to gray

1057-1067 Siltstone, dark gray to gray, some shell hash

1067-1076 Siltstone, very dark gray (10YR 3/1), some very fine quartz sand, glauconite (5%), siliceous microfossils (5%), calcareous nannofossils (5%), phosphorite (2%), zeolite (clinoptilolite), and a trace of foraminifera, clay matrix about 20%

1076-1085 Siltstone, sandy, clayey, dark gray to gray

1103-1113 Siltstone, sandy, clayey, dark gray

1113-1121 Shale, silty, dark gray

1131-1140 Siltstone, clayey, gray (5Y 5/1), some shell hash, glauconite (5%), framboidal pyrite (5%), calcareous nannofossils (10%), foraminifera (1%), and a trace of radiolarians, dolomite rhombs, muscovite, and chlorite, clay matrix about 30%

1140-1143 Siltstone, sandy, clayey, dark gray to gray

1149-1158 Siltstone, sandy, clayey, dark gray to gray

1158-1167 Siltstone, sandy, clayey, very dark gray

1176-1186 Siltstone, sandy, clayey, dark gray, slightly micaceous

1186-1195 Siltstone, gray (5Y 5/1), some calcareous nannofossils (5%), foraminifera (1%), volcanic glass (5%), pyrite (1%), zeolite (clinoptilolite), and a trace of sponge spicules, glauconite, mica (muscovite and chlorite), clay matrix about 30%, minor lithology is a very dark gray (5Y 3/1), organic-rich siltstone with a trace of volcanic glass

1195-1204 Siltstone, dark gray to gray

1204-1213 Siltstone, gray and a light gray calcareous siltstone

1213-1222 Limestone, light gray (5Y 7/2), micritic, minor lithology is a gray (10YR 5/1) sandy silt

1222-1231 Limestone, silty, light gray

1231-1241 Limestone, light gray to gray

1241-1250 Limestone, light gray to gray

1262-1271 Limestone, gray (5Y 6/1), micritic, some chert (20%), and a trace of glauconite, calcareous nannofossils, foraminifera, sponge spicules, pyrite, and quartz, clay matrix about 25%

1271-1280 Dolostone, calcareous, light gray to gray and a light gray limestone

1280-1289 Dolostone, calcareous, gray and a light gray limestone

1289-1298 Limestone, light gray, micritic and a gray dolostone

1298-1308 Limestone, light gray, micritic

1308-1317 Siltstone, very calcareous, gray

1317-1326 Limestone, light gray, (5Y 7/2), micritic, some mica (1% muscovite), calcareous nannofossils (2%), chert (20%), phosphorite, and traces of foraminifera and quartz, clay matrix about 15%

1326-1335 Siltstone, very calcareous, gray

1335-1344 Siltstone, very calcareous, gray and a light gray, micritic limestone

1344-1353 Siltstone, very calcareous, gray, a light gray micritic limestone, and a calcareous dolostone

1353-1362 Dolostone, gray, calcareous and a light gray, micritic limestone

1362-1372 Limestone, gray to light gray, micritic

1372-1381 Limestone, light gray (5Y 7/1), micritic, some very fine quartz sand, chert, and a trace of glauconite, clay matrix about 10%

1381-1390 Limestone, gray to light gray, micritic

1390-1399 Limestone, light gray to gray, micritic

1399-1408 Limestone, light gray to gray, micritic

1408-1417 Limestone, light gray to gray, micritic

1417-1427 Limestone, light gray to gray, micritic

1427-1436 Limestone, light gray (5Y 7/2), micritic, some quartz (10%), phosphorite (8%), zeolite, and traces of calcareous nannofossils and glauconite

1436-1445 Limestone, light gray to gray, micritic

1445-1453 Sandstone, silty, clayey, calcareous, limestone, light gray, micritic, and a gray, calcareous clayey siltstone

1453-1472 Siltstone, sandy, clayey, gray and a light gray micritic limestone

1472-1481 Siltstone, clayey, dark gray (5Y 4/1), some calcareous nannofossils (2%), framboidal pyrite (1%), mica (4% muscovite and 1% chlorite), foraminifera (1%), and a trace of glauconite and zircon, clay matrix about 40%, minor lithology is a light gray (5Y 7/2), micritic limestone

1481-1491 Siltstone, sandy, clayey, gray and a light gray, micritic limestone

1491-1500 Siltstone, sandy, clayey, gray and a light gray, micritic limestone

1500-1509 Siltstone, sandy, clayey, gray, and a light gray, micritic limestone, and a very fine grained sandstone

1509-1518 Siltstone, sandy, clayey, gray, and a light gray, micritic limestone, and a very fine grained sandstone

1518-1527 Siltstone, gray (5Y 5/1), friable, some sand, glauconite (trace), foraminifera (1%), and calcareous nannofossils (3%), clay matrix about 40%, minor lithology is a light gray (5Y 7/1), micritic limestone

1527-1536 Siltstone, sandy, clayey, gray and traces of a light gray limestone

1530-1545 Siltstone, sandy, clayey, gray and traces of a light gray, micritic limestone

1545-1554 Siltstone, clayey, gray (5Y 5/1), calcareous (30%), some quartz, mica (muscovite, chlorite, and biotite), and a trace of calcareous nannofossils, zircon, dolomite rhombs, and glauconite, clay matrix about 35%, minor lithology is a light gray, micritic limestone

1554-1564 Siltstone, sandy, clayey, gray and a coarse grained, very light gray limestone

1564-1573 Siltstone, clayey, gray, shell hash

1573-1582 Siltstone, clayey, gray and a light gray limestone

1582-1591 Siltstone, clayey, gray (5Y 5/1), calcareous (30%), some quartz (20%), calcareous nannofossils (1%), siderite (1%), glauconite (3%), framboidal pyrite (5%), mica (muscovite, chlorite, and biotite), and a trace of foraminifera, clay matrix about (30%), minor lithology is a light gray, cherty limestone

1591-1600 Siltstone, clayey, gray, shell hash and a light gray limestone

1600-1609 Siltstone, clayey, olive gray

1612-1619 Siltstone, clayey, some very fine sand, gray

1619-1628 Siltstone, clayey, gray (5Y 5/1), calcareous (30%), some quartz (15%), framboidal pyrite (2%), mica (10% muscovite, 3% chlorite, and 2% biotite), phosphorite (5%), and traces of calcareous nannofossils, glauconite, and siderite, clay matrix about 35%, minor lithology is a light gray, zeolitic limestone

1628-1637 Siltstone, clayey, gray, some allochthonous lignite

1637-1646 Siltstone, clayey, gray, a medium-coarse grained sandstone, and a light gray limestone

1646-1655 Siltstone, clayey, dark gray to gray

1655-1664 Sandstone, silty, clayey, median grain size 3.0-4.0 phi, very poorly sorted, angular-subangular, calcareous, light brownish gray (10YR 6/2), some zeolite (10%), lignite (1%), and traces of mica (muscovite, chlorite, and biotite), pyrite, glauconite, foraminifera, calcareous nanno- fossils, and zircon, clay matrix about 30%, minor lithologies are a light gray cherty limestone and a reddish brown iron-stained siltstone

1664-1673 Siltstone, clayey, dark gray to gray and a medium grained sandstone

1673-1683 Sandstone, silty, clayey, median grain size 2.0-3.0 phi, poorly sorted, subrounded, some mica (2% muscovite and chlorite), minor lithologies include a light gray (5Y 7/1) limestone, an iron stained shale (1%), and a shiny, black carbonaceous shale (1%)

1683-1692 Sandstone silty, clayey, medium grained, reddish brown

1692-1701 Sandstone, silty, clayey, median grain size 1.0-2.0 phi, poorly sorted, some gravel and lignite, light brownish gray (10YR 6/2), mostly quartz, some siderite (10%), calcareous

nannofossils (1%), and traces of framboidal pyrite, hematite, mica (muscovite, chlorite, and biotite), and foraminifera, clay matrix about 30%, minor lithologies include a pyrite-rich dark gray siltstone, a very light gray micritic limestone, and a reddish brown iron-stained (hematite) sandstone

1701-1710 Sandstone, silty, clayey, medium grained; a light gray limestone; and a gray siltstone

1714 Sandstone, silty, clayey, median grain size 3.5-4.0 phi, moderate sorting, cemented with calcite spar cement (33%), some mica (15% muscovite and chlorite), clay matrix about 8%, minor lithology is a gray shale

1719-1728 Sandstone, silty, clayey, gray and gray and reddish brown siltstones

1733 Sandstone, silty, clayey, median grain size 3.5 phi, poorly sorted, subangular, friable, noncemented, some carbonaceous matter, mica (muscovite, biotite, and chlorite), and devitrifying volcanic glass (2%), clay matrix about 15%

1737-1747 Sandstone, silty, clayey, medium grained, some gravel; a gray siltstone; and a light gray limestone

1747-1756 Sandstone, silty, clayey, fine grained, and a dark gray to gray siltstone

1756-1765 Sandstone, silty, clayey, fine grained; a gray siltstone; and a light gray limestone

1765-1774 Sandstone, silty, clayey, median grain size 2.0-3.0 phi, poorly sorted, subrounded, calcareous, some mica (muscovite, chlorite, and biotite), framboidal pyrite, traces of glauconite, foraminifera, and calcareous nanno-fossils, minor lithology is a light gray, sandy limestone

1774-1784 Sandstone, silty, clayey, fine grained and a gray clayey siltstone

1784 Siltstone, gray, some black carbonaceous grains up to 1 mm long, paralleling fissility, some mica (4% chlorite and 1% muscovite), traces of calcite, glauconite, biotite, and rock fragments of chert and quartzite, clay matrix about 17%, minor lithology interlaminated into the siltstone is a shale

1792-1798 Sandstone, silty, fine grained and a gray clayey siltstone

1816-1826 Sandstone, silty, clayey, fine grained and a gray, clayey siltstone

1826-1835 Siltstone, clayey, gray (5Y 5/1), some very fine sand, noncalcareous, some light gray (5Y 7/1), micritic limestone chips (5%)

1835-1844 Siltstone, clayey, some fine sand, lignite, and mica

1844-1853 Siltstone, clay, gray and a light gray limestone

1853-1862 Siltstone, clayey, gray and a light gray, cherty limestone

1862-1871 Limestone, gray (5Y 5/1), some quartz (10%), pyrite, mica (muscovite, chlorite, and biotite), traces of foraminifera, calcareous nannofossils, zircon, tourmaline, garnet and glauconite, clay matrix about 20%, minor lithology is a light gray, cherty limestone

1871-1881 Limestone, micritic, very light gray and a dark gray, clayey siltstone

1881-1890 Siltstone, clayey, gray and a light gray, micritic limestone

1890-1899 Siltstone, clayey, gray and a light gray, micritic limestone

1899-1908 Limestone, silty, clayey, gray (5Y 5/1), some very fine quartz sand, siderite nodules, foraminifera (2%), framboidal pyrite, and mica (5% chlorite, muscovite, and biotite), traces of glauconite, hornblende, and diatoms, clay matrix about 40%, minor lithology is a light gray, micritic limestone

1908-1917 Siltstone, clayey, gray and a very light gray, micritic limestone

1917-1926 Siltstone, clayey, gray and a very light gray, micritic limestone

1926-1935 Siltstone, clayey, gray and a very light gray, micritic limestone

1935-1945 Siltstone, clayey, gray to dark gray and a very light gray, micritic limestone

1945-1954 Limestone, gray (5Y 5/1), micritic, some silt-sized quartz (10%) and framboidal pyrite, clay matrix about 20%

1954-1963 Limestone, silty, slightly micaceous, gray

1963-1972 Siltstone, clayey, very calcareous, gray

1972-1981 Siltstone, clayey, very calcareous, gray

1981-1990 Sandstone, angular-subangular, median sand grain size 4.0 phi, gray (5Y 5/1), composed of quartz sand (55%), feldspar (5%), foraminifera (20%) with most of the remainder calcareous cement, second lithology (40% of interval) is a dolomitic shale, some glauconite with iron-stained rims on the dolomite rhombs

1993 Limestone, sandy, very light gray, sand is subangular and well-sorted, some glauconite (10%), matrix of carbonate micrite (60%)

2000-2009 Limestone, silty, gray; a calcareous sandstone; and a sandy, calcareous siltstone

2009-2018 Limestone, sandy, silty, gray, shell hash and a dark gray, calcareous siltstone

2018-2028 Limestone, sandy, gray (5Y 5/1) with zones of reddish iron staining, carbonate is micrite, quartz sand is 2.0-3.0 phi, subangular, and poorly sorted, minor lithology is a sandy, clayey siltstone

2028-2036 Limestones, light gray to gray

2036-2045 Limestones, gray to light gray and a dark gray, clayey siltstone

2045-2054 Limestone, gray, shell hash

2054-2064 Limestones, gray to light gray, shell hash

2066 Sandstone, gray, median grain size 1.5-2.5 phi, subangular, very poorly sorted, some glauconite, carbonaceous fragments (10%), lime mud matrix (20%)

2072 Sandstone, silty, very calcareous, light gray (5Y 7/1), median grain size 3.5-4.0 phi, moderately sorted, considerable carbonaceous matter (5%) and mica (20% chlorite, muscovite, and biotite), lime mud matrix (15%) and a trace of sparry calcite cement

2075 Siltstone, dark gray, sandy, some carbonaceous matter (15%), mica (7% chlorite, 5% muscovite, and 5% biotite), siltstone rock fragments (4%), foraminifera and calcareous nannofossils (2%), and traces of glauconite, hornblende, and zircon, clay matrix about 25%

2082-2091 Sandstone, very calcareous, fine grained, gray and gray to light gray limestones

2091-2100 Sandstone, silty, clayey, median grain size 3.5-4.0 phi, moderately sorted, subangular, some mica (8% muscovite, 5% chlorite, 2% biotite), traces of dolomite rhombs, framboidal pyrite, glauconite, foraminifera, zircon, tourmaline, garnet, and hornblende, clay matrix about 30%, minor lithology is a light gray, micritic limestone

2100-2109 Sandstone, very calcareous, fine grained, gray and gray to light gray limestones

2109-2118 Sandstone, very calcareous, fine grained, gray; gray to light gray limestones; and a dark gray siltstone

2118-2128 Sandstone, very calcareous, fine grained, gray; gray to light gray limestones, and a dark gray siltstone

2128-2137 Siltstone, sandy, dark gray (2.5Y 4/0), noncalcareous, abundant carbonaceous matter (15%) and mica (15% chlorite, muscovite and biotite), foraminifera (5%), trace of glauconite, hornblende, brown tourmaline, calcareous nannofossils, and zircon, clay matrix about 25%

2137-2146 Sandstone, very calcareous, fine grained, gray and gray to light gray limestones

2146-2155 Sandstone, very calcareous, fine grained, gray; gray to light gray limestones; and a dark gray siltstone

2155-2164 Sandstone, very calcareous, fine grained, gray; gray to light gray limestones; and a dark gray siltstone

2164-2173 Limestone, dark gray (5Y 4/1), sandy, silty, clayey, micritic, some silt and very fine sand-sized quartz (10%), framboidal pyrite (10%), siderite (5%), mica (muscovite, chlorite, and biotite), trace of glauconite and dolomite rhombs, clay matrix about 20%, minor lithology is a light gray micritic limestone

2173-2182 Limestone, silty, gray, shell hash

2182-2192 Limestones, gray to light gray

2192-2201 Limestones, very light gray to gray

2201-2209 Limestones, gray to light gray, some iron staining

2209-2219 Limestones, gray to light gray, micritic

2222 Limestone, greenish gray, very fine sand- to coarse silt-sized, angular-subangular quartz (35%), lime mud matrix (60%), traces of glauconite

2228-2234 Limestone, sandy, micritic matrix, brownish gray

2249-2259 Limestone, grayish brown (2.5Y 5/2), sandy, some calcareous nannofossils (3%) and mica (2% muscovite, 1% chlorite, trace biotite), traces of glauconite, framboidal pyrite, siderite, and foraminifera, clay matrix about 25%, minor lithologies are a light gray glauconitic limestone and a medium grained quartz sand

2265-2274 Sandstone, medium grained, slightly micaceous, gray

2274-2283 Sandstone, medium grained, slightly micaceous, gray and a gray siltstone

2283-2292 Sandstone, silty, clayey, median grain size 1.0-2.0 phi, poorly sorted, subrounded, light brownish gray (2.5Y 6/2), sand is mostly quartz grains, some olive gray (5Y 5/2) limestone chips (10%), mica (3% muscovite and chlorite), red iron-stained shale (1%), and black, organic-rich shale chips

2292-2301 Siltstone, gray to dark gray, and a silty sandstone

2301-2310 Sandstone, medium grained, slightly micaceous, gray

2310-2319 Siltstones, sandy, gray to dark gray

2338-2347 Siltstone, sandy, slightly micaceous, gray and a light gray limestone

2347-2356 Sandstone, gray (5Y 5/1), median grain size 3.0-4.0 phi, poorly sorted, subangular, some sand-sized muscovite flakes, foraminifera (1%), calcareous nannofossils (5%), and siderite (5%), traces of glauconite, chlorite, framboidal pyrite, and dolomite rhombs, clay matrix about 35%, minor lithologies are a gray siltstone and a light gray, cherty, zeolitic limestone

2356-2365 Sandstone, silty, clayey, gray, slightly micaceous and a gray siltstone

2365-2374 Siltstone, sandy, clayey, gray and a medium grained sandstone

2374-2384 Sandstone, silty, clayey, slightly micaceous, gray and a dark gray siltstone

2384-2393 Sandstone, gray (5Y 5/1), median grain size 3.0-4.0 phi, poorly sorted, subangular, mostly quartz, some siderite (1%), pyrite (1%), mica (muscovite, chlorite, and biotite), foraminifera (2%), and calcareous nannofossils (2%), traces of glauconite, zircon, green hornblende, and tourmaline, minor lithologies are a light gray cherty limestone and a brownish gray, siderite-rich siltstone

2393-2402 Siltstones, sandy, clayey, gray to dark gray

2402-2411 Siltstones, sandy, clayey, gray to dark gray

2411-2420 Siltstones, sandy, clayey, gray to dark gray

2429-2432 Sandstone, gray (5Y 5/1), median grain size 3.0-4.0 phi, silty, poorly sorted, subrounded, sand is mostly quartz, some mica (3% muscovite, 1% chlorite, 1% biotite), calcareous nannofossils (5%), foraminifera (1%), glauconite (1%), framboidal pyrite (5%), siderite (3%), traces of blue tourmaline and zircon, minor lithology is a black, carbonaceous siltstone

2438-2448 Sandstone, silty, light brownish gray (2.5Y 6/2), median grain size 1.0-2.0 phi, poorly sorted, subrounded, some mica (3% muscovite and chlorite), carbonaceous black shale (12%), calcareous nannofossils (5%), foraminifera (trace), minor lithologies include a light gray (5Y 7/2) micritic limestone, a reddish brown iron-stained shale, and a reddish brown iron-stained siltstone

2448-2457 Sandstone, silty, medium grained, slightly micaceous and a dark gray shale

2457-2466 Sandstone, silty, medium grained, slightly micaceous and a gray siltstone

2466-2475 Sandstone, silty, medium grained, slightly micaceous and a dark gray shale

2475-2484 Sandstone, silty, medium grained, slightly micaceous and a dark gray shale

2484-2493 Siltstones, sandy, clayey, gray to dark gray and a medium grained sandstone

2493-2503 Sandstone, silty, light gray (5Y 6/1), median grain size 3.5-4.0 phi, poorly sorted, subrounded, friable, calcareous (32% lime mud cement), some opaque minerals and carbonaceous matter (4%), mica (4% muscovite and chlorite), and traces of zircon, hornblende, and sphene, clay matrix about 12%

2503-2512 Sandstone, silty, clayey and a gray siltstone

2512-2521 Sandstone, silty, clayey, medium grained and gray to dark gray siltstones and shales

2521-2530 Sandstone, gray (5Y 5/1), median grain size 2.5-3.5, silty, poorly sorted, subrounded-subangular, calcareous, mostly quartz, some calcareous nannofossils (10%), foraminifera (1%), siderite (2%), framboidal pyrite (4%), mica (2% muscovite and a trace of chlorite and biotite), traces of glauconite, dolomite rhombs, blue tourmaline, and zircon, clay matrix about 15%, minor lithologies are a dark gray shale and a light gray, sandy limestone

2530-2539 Siltstones, sandy, clayey, gray to dark gray and a medium grained sandstone

2539-2548 Sandstone, silty, clayey and gray to dark gray siltstones and shales

2548-2557 Sandstone, silty, clayey and gray to dark gray siltstones and shales

2557-2567 Siltstones and shales, gray-very dark gray, some iron staining

2567-2576 Sandstones, silty, medium-fine grained

2576-2585 Sandstone, silty, clayey, medium-fine grained and a gray siltstone

2585-2594 Sandstone, silty, clayey, light brownish gray (2.5Y 6/2), median grain size 2.0-3.0 phi, moderately sorted, subrounded, some mica (3% muscovite and chlorite), siderite (2%), and traces of glauconite and calcareous nanno- fossils, minor lithologies include a gray (7.5YR 5/0) shale (10%), a light gray (2.5Y 7/2) micritic limestone, and reddish brown iron- stained siltstone (1%)

2594-2603 Sandstone, very light gray, median grain size 3.0-3.5 phi, moderately sorted, laminated, friable, noncalcareous, sand is mostly quartz, some brown devitrifying volcanic glass (10%), and carbonaceous fragments

2603-2612 Sandstone, silty, clayey, medium-very fine grained and gray to dark gray siltstones

2612-2621 Sandstone, silty, clayey, slightly micaceous and gray to dark gray siltstones

2621-2631 Siltstones, sandy, clayey, dark gray to gray and a sandstone

2631-2640 Sandstone, gray (5Y 5/1), median grain size 3.0-4.0 phi, silty, poorly sorted, subangular, calcareous (35%), some phosphorite (3%), glauconite (1%), siderite (1%), calcareous nannofossils (5%), mica (muscovite, chlorite, and biotite), traces of tourmaline and shell hash, minor lithology is a micaceous, dark gray shale

2640-2649 Sandstone, silty, clayey and a gray siltstone

2649-2658 Sandstone, silty, some gravel

2658-2667 Sandstone, silty, medium-coarse grained, some mica

2667-2676 Sandstone, silty, medium grained and dark gray to gray siltstones

2676-2685 Sandstone, olive gray (5Y 5/2), median grain size 3.0-4.0 phi, silty, clayey, poorly sorted, subrounded, some mica (10% muscovite, 4% chlorite, 1% biotite), framboidal pyrite (1%), traces of calcareous nannofossils, foraminifera, siderite, and glauconite, clay matrix about 30%, minor lithologies include a dark gray micaceous shale, a light gray micritic limestone, and phosphorite nodules

2685-2695 Sandstone, silty, clayey, medium-fine grained and dark gray to gray siltstones

2695-2704 Siltstone, sandy, clayey, gray; a fine grained sandstone; and a dark gray shale

2712-2722 Sandstone, coarse grained, some gravel and a light gray siltstone

2722-2731 Sandstone, silty, coarse-medium grained and gray to dark gray siltstones

2731-2740 Sandstone, silty, light brownish gray (2.5Y 6/2), moderately sorted, subrounded, trace of lignite, some mica (1% muscovite and chlorite) and gravel sized quartz grains, some very dark gray (2.5Y 3/0) carbonaceous shale, light gray (5Y 7/2) micritic limestone, and reddish brown iron-stained shale (3%)

2740-2749 Siltstones, gray to dark gray and a medium grained sandstone

2749-2759 Siltstones, gray to dark gray; a medium grained sandstone; and a light gray limestone

2759-2768 Sandstone, silty, clayey, medium grained and gray to dark gray siltstones

2768-2777 Sandstone, silty, clayey, medium grained and gray to dark gray siltstones

2777-2786 Sandstone, silty, clayey, medium grained and gray to dark gray siltstones

2795-2804 Sandstone, light gray (5Y 6/1), median grain size 2.0-3.0 phi, some gravel, mostly quartz, poorly sorted, subrounded, some foraminifera (5%), calcareous nannofossils (2%), mica (10% muscovite, 1% chlorite, and a trace of biotite), traces of glauconite, framboidal pyrite, siderite,

and dolomite rhombs, clay matrix about 20%, minor lithology is a dark gray siltstone

2804-2813 Sandstone, silty, light gray and some dark gray siltstone

2813-2823 Sandstone, light gray, medium grained and a very micaceous siltstone

2825 Sandstone, light gray (5Y 7/1), median grain size 3.0-3.5 phi, moderately sorted, friable, noncemented, noncalcareous, some devitrifying volcanic glass (5%) and lignite (5-10%), traces of sphene and zircon, clay matrix about 8%

2829 Sandstone, white to light gray, very fine grained, moderately sorted, friable, non- cemented, clay matrix about 7%

2832-2841 Sandstone, medium-fine grained; gray to dark gray siltstones; and a sandy limestone

2844 Coal, lignitic and a dark gray siltstone

2847-2850 Sandstone, gray (5Y 5/1), median grain size 3.0-4.0 phi, silty, clayey, poorly sorted, subrounded, some foraminifera (5%), lignite fragments (15%), calcareous nannofossils (2%), mica (15% muscovite and 1% chlorite), traces of glauconite, tourmaline, green hornblende, and pyritized diatoms, clay matrix about 25%, minor lithology is a gray shale

2850-2860 Siltstone, sandy, clayey, gray and a fine grained sandstone

2874-2877 Sandstone, medium grained, well sorted and a dark gray siltstone

2877-2887 Siltstone, sandy, clayey, gray and a fine grained sandstone

2893-2896 Sandstone, light olive gray (5Y 6/2), median grain size 1.5-2.5 phi, moderately sorted, subrounded, some friable goethite- and siderite-stained clasts, mica, and lignite, minor lithologies include a dark gray (2.5Y 4/0) shale, a black (2.5Y 2/0) carbonaceous shale, and a light gray (5Y 7/1), micritic limestone

2920-2923 Sandstone, gray (5Y 5/1), median grain size 3.0-4.0 phi, moderate sorting, subrounded, some foraminifera (5%), framboidal pyrite (5%), and mica (4% muscovite, 1% chlorite), traces of glauconite and calcareous nannofossils, minor lithologies include a dark gray shale and a sandy, zeolitic limestone

2935-2938 Siltstones, gray to dark gray and a medium-fine grained sandstone

2954-2957 Limestone, light brownish gray (10YR 6/2), some quartz sand (20%), foraminifera (5%), calcareous nannofossils (10%), glauconite (1%), phosphorite (2%), opaline chert (30%), and siderite (3%), mica (15% muscovite and a trace of chlorite) traces of zircon, tourmaline, pyritized radiolarians, and pyrite, minor lithology is a is a dark gray shale

2972-2975 Siltstone, sandy, gray; light gray sandy limestone; and a fine grained sandstone

2987-2990 Sandstone, gray (5Y 5/1), median grain size 2.5-3.5 phi, moderately sorted, subrounded, friable, noncemented, mostly quartz, some sand sized muscovite flakes, foraminifera (2%), calcareous nannofossils (1%), framboidal pyrite (2%), and mica (10% muscovite, a trace of chlorite), traces of glauconite, brown tourmaline and garnet, minor lithology is a dark gray siltstone

3043 Sandstone, light gray, moderately sorted quartz with abundant very fine-coarse sand sized muscovite flakes, some devitrifying volcanic glass shards (2%) and a trace of biotite, clay matrix about 8%

3048 Sandstone, light gray, median grain size 3.0-4.0 phi, poorly sorted, foliated by parallelism of muscovite flakes (5%), some carbonaceous matter and traces of chert and shale rock fragments, clay matrix about 4%

3060-3063 Sandstone, silty, clayey, light brownish gray (2.5Y 6/2), median grain size 2.0-3.0 phi, moderately sorted, subrounded, trace of lignite, siderite-bearing friable clasts, and some mica (5% muscovite and chlorite), foraminifera (2%), calcareous nannofossils (5%), glauconite (1%), and pyrite (5%), minor lithologies include a black carbonaceous shale (7%) and a light gray, micritic limestone

3076-3079 Sandstone, silty, slightly micaceous

3094-3097 Limestone, light gray (5Y 7/1), sandy (quartz sand about 10%), zeolite (clinoptilolite 10%), opaline chert (5%), lignite (5%), foraminifera (20%), calcareous nannofossils (25%), mica (10% muscovite and trace chlorite and biotite), traces of glauconite, pyrite, zircon, and tourmaline

3120 Sandstone, light gray, median grain size 3.0-4.0 phi, interlaminated with carbonaceous matter (3% coal) and mica (9% chlorite and 6% muscovite), friable, noncalcareous, traces of hornblende and zircon, clay matrix about 3%

3143-3146 Siltstone, sandy, clayey, gray; a fine grained sandstone; a dark gray shale; and a lignitic coal

3167-3170 Sandstone, gray (5Y 5/1), median grain size 3.0-4.0 phi, poorly sorted, subrounded, friable, some lignite (2%), calcareous nannofossils (5%), framboidal pyrite (5%), and mica (8% muscovite, 1% chlorite, trace biotite), traces of siderite, foraminifera, glauconite, green tourmaline, and zircon, clay matrix about 30%, minor lithology is a dark gray siltstone

3197 Coal, lignitic, with rare fragments of very light gray, noncalcareous siltstone

3200 Sandstone, light gray, very fine grained, moderately sorted, many medium sand sized muscovite flakes, friable, noncalcareous, non- cemented, some carbonaceous fragments and traces of devitrifying volcanic glass, clay matrix about 28%

3216-3219 Shale, sandy, silty, clayey, light brownish gray (2.5Y 6/2), some lignite, mica (5% chlorite and muscovite), calcareous nannofossils (1%), traces of glauconite and foraminifera, and a clay matrix of about 60%, minor lithologies include a dark gray (2.5Y 4/0) shale, light brownish gray (2.5Y 6/2) limestone, chert (1%), and reddish brown iron-stained shale

3225-3226 Sandstone, very light gray, median grain size 3.5-4.0 phi, very poorly sorted, calcite cement 25%, traces of devitrified volcanic glass and silicified oolites, friable, some mica (5% chlorite and a trace of muscovite), and traces of zircon and glauconite

3228-3231 Shale, silty, dark gray; a lignitic coal; a gray siltstone; and a very fine grained sandstone

3246-3249 Sandstone, dark gray (5Y 4/1), median grain size 3.0-4.0 phi, some foraminifera (2%), siderite (5%), calcareous nannofossils (5%), framboidal pyrite (1%) and mica (1% muscovite and traces of chlorite and biotite), traces of dolomite rhombs, glauconite, zeolite, and brown tourmaline, minor lithologies are a coal and a dark gray shale

3265-3268 Shale, dark gray, silty and a lignitic coal

3283-3286 Sandstone, light gray (5Y 6/1), median grain size 3.0-4.0 phi, friable, poorly sorted, subrounded, calcareous, some foraminifera (2%), calcareous nannofossils (5%), siderite (5%), framboidal pyrite (1%), zeolite (2%), and mica (1% muscovite and traces of chlorite and biotite), traces of green tourmaline, dolomite rhombs, and glauconite, minor lithologies are a coal and a dark gray, carbonaceous shale

3295-3298 Coal, lignitic and a dark gray siltstone

3313-3316 Sandstone, light gray sandstone (5Y 6/1), median grain size 3.0-4.0 phi, poorly sorted, subrounded, friable, calcareous, some siderite (2%), foraminifera (2%), glauconite (1%), and calcareous nannofossils (2%), traces of zeolite, muscovite, chlorite, and biotite, clay matrix about 20%, minor lithologies are a coal and a dark gray, carbonaceous shale

3326 Sandstone, very light gray, median grain size 3.5-4.0 phi, very poorly sorted, friable, non-calcareous, interlaminated with 1-4 mm thick layers of sand, carbonaceous matter, and sand sized mica flakes, carbonaceous matter 5% of sandstone and 50% of laminae, some quartzite rock fragments, clay matrix about 20%

3329-3332 Siltstone, clayey, dark gray and a lignitic coal

3341-3344 Sandstone, silty, slightly micaceous, some lignite

3356-3359 Sandstone, grayish brown, median grain size 3.5-4.0 phi, subangular-subrounded, carbonaceous matter (lignite) 5%, some iron staining present, mica (15% muscovite and chlorite), noncalcareous, siderite (2%), and traces of foraminifera, calcareous nannofossils and glauconite, clay matrix about 35%, minor lithologies include black organic-rich shale (15%), light gray micritic limestone (5%) and some siderite-bearing shale (1%) chips

3371-3374 Siltstone, dark gray (5Y 4/1), sandy, some mica (15% muscovite, 3% biotite, and trace chlorite), carbonaceous matter 25%, traces of siderite, foraminifera, calcareous nannofossils, framboidal pyrite, friable, noncemented, clay matrix about 40%, minor lithologies are a coal (lignite) and a fine grained sandstone

3382 Sandstone, light gray, median grain size 3.5-4.0 phi, poorly sorted, laminated with occasional gray shale laminae, very calcareous, traces of brown hornblende and devitrifying volcanic glass

3386-3389 Shale, silty, dark gray

3394 Sandstone, light gray, median grain size 3.5-4.0 phi, poorly sorted, friable, noncalcareous, interlaminated with dark laminae composed of carbonaceous matter and muscovite, sandstone contains 40% quartz, 15% clay mineral matrix, 20% mica (muscovite and biotite), and trace amounts of quartzite rock fragments and zircon, dark laminae contain carbonaceous matter (30%) and mica (20% muscovite and 10% biotite)

3396 Sandstone, light gray, median grain size 3.5-4.0 phi, poorly sorted, laminae present rich in clay or lime mud matrix, friable, noncemented, some muscovite and chlorite, traces of biotite

3402-3405 Siltstone, clayey, dark gray; a lignitic coal; and a fine grained sandstone

3420-3423 Sandstone, gray (5Y 5/1), median grain size 3.0-4.0 phi, moderately sorted, subrounded, carbonaceous matter 15%, some mica (20% muscovite and a trace of chlorite), trace of foraminifera, calcareous nannofossils, pyrite, and glauconite, clay matrix about 30%, minor lithologies include a dark gray siltstone and a light gray, cherty, calcareous siltstone

3432 Sandstone, light gray, very fine grained, poorly sorted, laminated with layers of muscovite and carbonaceous matter, traces of biotite, zircon, and hornblende-bearing quartz, clay matrix about 22%

3434 Sandstone, very light gray, median grain size 3.5-4.0 phi, poorly sorted, traces of calcareous microfossil fragments (foraminifera), clay matrix about 20%, dark laminae composed of carbonaceous matter and muscovite

3437 Sandstone, light gray, median grain size 3.0-4.0 phi, poorly sorted, friable, noncemented, some muscovite (4%), carbonaceous matter (2%), devitrifying volcanic glass, with traces of biotite, hornblende, garnet, and fragments of quartzite, clay matrix about 18%

3453-3457 Sandstone, light brownish gray (10YR 6/2), median grain size 2.5-3.5 phi, friable, some mica (10% muscovite and traces of chlorite and biotite), siderite (1%), and carbonaceous matter (5%), trace of calcareous nannofossils, framboidal pyrite, glauconite, foraminifera, and zircon, clay matrix about 20%, minor lithologies are a dark gray siltstone and a light gray, cherty limestone

3469-3472 Siltstones and shales, dark gray to gray and a light gray limestone

3484-3487 Sandstone, silty, clayey, fine grained, slightly micaceous and a dark gray shale

3494-3495 Shale, medium dark gray, some very fine sand, clay matrix about 51%, second lithology is a white shaley micritic limestone, some small iron-stained spots and sparce glauconite, mica (5% muscovite, 1% biotite, and 1% chlorite), calcite cement, traces of chert fragments and zircon, clay matrix about 40%

3499-3502 Sandstone, silty, clayey, fine grained; a dark gray siltstone; a lignitic coal; and a light gray limestone

3518-3521 Sandstone, light olive gray (5Y 6/2), median grain size 3.0-4.0 phi, moderately sorted, subangular, silty, micaceous (30% muscovite with a trace of chlorite and biotite), some lignite (5%), traces of glauconite, green hornblende, zircon, and calcareous nannofossils, clay matrix 30%, minor lithologies include a dark gray (7.5YR 4/0), micaceous shale, a light gray (5Y 7/2), micritic, cherty limestone, and a sandy limestone

3525 Siltstone, gray, fissile, clay matrix about 35%, contains sparce laminae (.5mm) of a very fine grained angular-subangular, friable, light gray sandstone

3529 Siltstone, light gray, some very fine sand, calcite cement (5%), rock fragments of chert, carbonaceous matter (15%), and muscovite (5%), with traces of biotite and zircon, clay matrix about 25%

3533-3536 Siltstone, clayey, dark gray; a fine grained sandstone; and a lignitic coal

3548-3551 Sandstone, light gray, median grain size 3.5-4.0 phi, poorly sorted, faintly foliated due to parallelism of muscovite flakes (5% muscovite, 3% biotite, and 2% chlorite), some chert fragments and calcite cement, traces of zircon, clay matrix 10%, minor lithology is a black, carbonaceous shale

3560 Limestone, light gray, silty with black carbonaceous matter, grains up to 1mm long and brownish iron-stained speckles

3563-3566 Sandstone, fine grained; gray and dark gray siltstones; and a light gray limestone

3578-3582 Sandstone, light gray (5Y 6/1) median grain size 3.0-4.0 phi, moderately sorted, subangular-subrounded, some siderite (4%), carbonate cement, carbonaceous matter (3%), traces of dolomite rhombs, calcareous nannofossils, foraminifera, and zircon, clay matrix about 8%, minor lithology is a black siltstone

3593 Sandstone, very light gray, median grain size 3.5-4.0 phi, poorly sorted, friable, noncemented, noncalcareous, some sand- and coarse silt-sized muscovite flakes, with traces of biotite, sphene, and quartz with hornblende inclusions, clay matrix about 10%

3594-3597 Coal, lignitic; a dark gray shale; and a light gray limestone

3609-3612 Siltstone, dark gray (2.5Y 4/1), some siderite, mica (50% muscovite, 5% chlorite), traces of tourmaline and hornblende, clay matrix about 10%, minor lithology is a light gray, slightly micaceous sandstone

3624-3626 Siltstone, gray to dark gray; a light gray limestone; and a lignitic coal

3638 Siltstone, gray, shaly, sandy, interlaminated with a very light gray sandstone, contains only traces of carbonate, clay matrix about 20%, Sandstone laminae are very fine grained, moderately calcareous, and contain abundant carbonaceous matter on the plane of lamination

3640-3642 Sandstone, very light gray, very fine grained, poorly sorted, angular-subangular, matrix of lime mud, micaceous (30% muscovite and a trace of chlorite), trace of foraminifera and 2%

calcareous nannofossils, minor lithology is a black, carbonaceous, micaceous shale

3655-3658 Sandstone, silty, medium grained, calcite cemented, micaceous and a dark gray siltstone

3670-3673 Siltstone, very dark gray (7.5YR 3/0), shaly, with some very fine sand, micaceous (40% muscovite with a trace of chlorite), siderite (2%), glauconite (trace), clay matrix about 15 %, friable, noncalcareous except for a trace of calcareous nannofossils, minor lithology is a light brownish gray, silty sand

3675 Sandstone, interlaminated medium gray (1-4 mm) and black (.5-1 mm) layers, both fine grained and very poorly sorted, carbonaceous matter (20%) in black laminae, some microcrystalline quartz cement (5%), biotite (5%), chlorite (1%), and lime mud matrix (2%), clay matrix about 6%

3685-3688 Sandstone, fine grained and a dark gray siltstone

3700-3703 Sandstone, light gray (5Y 6/1), median grain size 3.0-4.0 phi, friable, some carbonaceous matter (1% lignite) and mica (25% muscovite and a trace of chlorite), calcareous, traces of calcareous nannofossils, minor lithology is a dark gray, micaceous siltstone

3719-3722 Siltstone, dark gray (5Y 4/1), sandy, some mica (40% muscovite, 5% chlorite), clay matrix about 10%, trace of siderite, pyrite, zeolite, green tourmaline, and green hornblende

3734-3737 Sandstone, silty, fine grained and dark gray to gray siltstones

3740-3741 Sandstone, very light gray, median grain size 3.0-4.0 phi, poorly sorted, friable, noncemented, slightly micaceous (5% muscovite, 3% biotite, and a trace of chlorite), dark laminae composed of carbonaceous material and mica are present in 1mm thick laminations, clay matrix about 10%, traces of glauconite, sparry calcite cement, quartzite rock fragments, hornblende, and quartz with inclusions of hornblende

3752-3755 Sandstone, gray (5Y 6/1), median grain size 2.5-3.5 phi, moderately sorted, subrounded, some mica (10% muscovite and traces of chlorite and biotite), traces of siderite and pyrite, clay matrix about 5%, minor lithology is a dark gray, micaceous shale

3766 Sandstone, very light gray, median grain size 3.0-3.5 phi, poorly sorted, friable, noncemented, 10% opaque minerals and carbonaceous matter, mica (4% muscovite, 1% chlorite), with traces of carbonate cement, quartzite and chert rock fragments, hornblende, biotite, and zircon

3770-3774 Siltstones, clayey, dark gray to gray and a medium-fine grained sandstone

3786-3789 Sandstone, gray (10YR 6/1), median grain size 3.0-4.0 phi, poorly sorted, subrounded, some mica (5% muscovite and a trace of chlorite), siderite (1%), friable, noncemented, traces of framboidal pyrite, minor lithology is a dark gray siltstone

3813-3816 Sandstone, light brownish gray (10YR 6/2), median grain size 1.0-2.0 phi, moderately sorted, subangular, some mica (muscovite 5%, chlorite trace), friable, noncalcareous, minor lithologies include a very dark gray (7.5YR 3/0) shale and a light gray, micritic carbonate

3828-3831 Sandstone, light brownish gray (10YR 6/2), median grain size 3.0-4.0 phi, moderately sorted, subrounded, some mica (10% muscovite and a trace of chlorite), siderite (1%), trace of calcareous nannofossils, minor lithology is a dark gray siltstone

3844-3847 Sandstone, silty, clayey, calcite cemented, medium-fine grained and a dark gray siltstone

3856-3859 Sandstone, light brownish gray (10YR 6/2), median grain size 2.5 phi, poorly sorted, subangular, friable, noncalcareous, some mica (10% muscovite and a trace of chlorite), minor lithology is a dark gray, micaceous shale

3871-3874 Sandstone, silty, clayey, fine grained, calcite cemented and a dark gray siltstone

3886-3889 Sandstone, silty, medium-fine grained, calcite cemented and a dark gray siltstone

3892-3895 Sandstone, light brownish gray (10YR 6/2), median grain size 2.0-3.0 phi, poorly sorted, subangular, friable, noncalcareous except for a trace of calcareous nannofossils, some lignite and mica (10% muscovite and a trace of chlorite), minor lithologies include a dark gray, micaceous shale and a light gray, micritic limestone