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

by

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This report is preliminary and has not been reviewed for conformity with U.S. Geological Survey editorial standards and stratigraphic nomenclature. Any use of trade names is for descriptive purposes only and does not imply endorsement by the USGS.

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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 occurring in the silt fraction, to detect amorphous phases or those occurring 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. Although 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 throughout
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.

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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.
<p>| SAMPLE DEPTH | SMG | C-S | I-S | CHL | I/M | KAO | GLA | QTZ | DC | FLD | CAL | ARA | D/A | SID | HEM | GQE | PYR | APA | AMP | ZED | COMMENTS |
|--------------|-----|-----|-----|-----|-----|-----|-----|-----|----|-----|-----|-----|-----|-----|-----|-----|-----|-----|-----|-------|
| 171-189      | 1   | 1   | 5   | 71  | 17  | 4   | T   | T   | T  | washed silty sand |
| 226-235      | 2   | 5   | T   | 85  | 6   | T   | T   | washed sand |
| 271-280      | 2   | 5   | T   | 83  | 8   | T   | T   | washed sand |
| 299-308      | 2   | 4   | T   | 76  | 15  | I   | T   | washed sand |
| 390-399      | T   | 68  | 4   | 11  | 5   | 11  | washed gravel, flint hash |
| 445-454      | T   | 2   | 60  | 2   | 6   | 22  | 2   | 4   | washed gravel, spinules |
| 500-509      | T   | 3   | 6   | 5   | T   | 48  | 2   | T   | 23  | T   | 11  | washed sand, spinules |
| 555-564      | T   | 5   | 11  | 4   | 13  | 49  | 2   | 6   | 2   | 6   | washed 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   | 1  | 65  | 4   | T   | 6   | 20  | washed sand |
| 783-786      | 2   | 8   | 7   | 9   | 16  | 2   | 52  | 3   | DG siltstone |
| 783-786      | T   | 4   | 3   | 7   | 19  | 2   | 63  | 1   | DG nodules |
| 838-847      | T   | T   | 1   | 1   | T   | 23  | 1   | T   | 4   | 68  | washed sand |
| 903-902      | T   | 2   | 6   | 12  | 10  | T   | 43  | 5   | 1   | T   | 13  | DG siltstone |
| 903-902      | T   | T   | 8   | 10  | 16  | T   | 33  | 5   | 3   | T   | 12  | 10  | G silty clayey sandstone |
| 948-957      | 4   | 5   | 5   | 5   | 1   | 10  | 1   | T   | 6   | 5   | 5   | washed sand |
| 948-957      | T   | 3   | 10  | 14  | 13  | T   | 20  | 3   | 21  | T   | 4   | 11  | G silty sandstone |
| 1003-1012    | 1   | 5   | 10  | 12  | 11  | T   | 27  | 4   | 22  | 2   | 5   | G diatomaceous shale |
| 1067-1076    | 7   | 1   | 3   | 5   | 5   | 6   | 5   | 14  | 14  | 2   | 25  | 6   | T   | 5   | 5   | 3   | G 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   | DG cherty calcareous siltstone |
| 1131-1140    | T   | 2   | 5   | 4   | 5   | 19  | 19  | 2   | 17  | 10  | 5   | T   | T   | G cherty calcareous siltstone |
| 1186-1195    | 16  | I   | 3   | 3   | 4   | T   | 19  | 13  | 2   | 26  | T   | 6   | 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   | 2   | 3   | 2   | T   | 7   | 10  | T   | 38  | 15  | 8   | DG cherty limestone |
| 1262-1271    | 11  | I   | 1   | T   | 2   | T   | 79  | 5   | T   | G micritic limestone |
| 1317-1326    | 7   | I   | 2   | T   | 20  | 71  | LG cherty micritic limestone |
| 1317-1326    | 11  | I   | 1   | T   | 75  | 8   | W micritic limestone |
| 1371-1381    | 9   | T   | 1   | T   | 4   | 7   | 41  | T   | 2   | 33  | G limestone |
| 1371-1381    | 7   | T   | 1   | T   | 27  | T   | 59  | T   | 3   | LG cherty limestone |
| 1371-1381    | 5   | 2   | 1   | T   | 28  | 59  | T   | 2   | W cherty limestone |
| 1427-1436    | 6   | 3   | 3   | T   | 3   | 72  | I   | 8   | 3   | G limestone |
| 1427-1436    | 16  | I   | T   | T   | 12  | 57  | T   | LG limestone |
| 1472-1481    | 16  | T   | 9   | 8   | T   | 18  | 3   | 29  | T   | 2   | 4   | calcareous siltstone |</p>
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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 provenance. 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.

Glaucconite, 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 noticeably 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 frambooidal 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


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 frambooidal 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, frambooidal 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 frambooidal 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 frambooidal 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 frambooidal pyrite, mostly quartz, partially washed, some euhedral and frambooidal 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 frambooidal 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 frambooidal 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%

1076-1105  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%), frambooidal 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, 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%), frambooidal 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%), frambooidal 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, chloride, and biotite), pyrite, glauconite, foraminifera, calcareous nannofossils, 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 frambooidal 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), frambooidal pyrite, traces of glauconite, foraminifera, and calcareous nannofossils, 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%), frambooidal 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, 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, frambooidal 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, frambooidal 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%), frambooidal 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%), frambooidal 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 nannofossils. 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, dark 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%), framboideal pyrite (5%), and mica (8% muscovite, 1% chloride, 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%), framboideal 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%), framboideal 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, framoidal 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, framoidal 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 sparse 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 sparse 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.