OCS Report
MMS 2000-033

EXXON LYDONIA CANYON BLOCK 133 No. 1 WELL

Geological and Operational Summary

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ABBREVIATIONS

API	--	American Petroleum Institute
bbl	--	barrels
BOP	--	Blow out preventer
CNL	--	Compensated neutron log
CPI	--	Carbon Preference Index
COST	--	Continental Offshore Stratigraphic Test
DST	--	drill stem test
EQMW	--	equivalent mud weight
FDC	--	compensated formation density log
FEL	--	from east line
FNL	--	from north line
FSL	--	from south line
FWL	--	from west line
k	--	permeability
KB	--	kelly bushing
LS	--	limestone
m	--	meter (s)
md	--	millidarcy
MYBP	--	million years before present
OCS	--	Outer Continental Shelf
ppf	--	pounds per foot
ppg	--	pounds per gallon
ppm	--	parts per million
psi	--	pounds per square inch
R_O	--	vitrinite reflectance
SS	--	sandstone
Sw	--	water saturation
TAI	--	thermal alteration index
TD	--	total depth
TIOG	--	threshold of intense oil generation
TOC	--	total organic carbon
UTM	--	Universal Transverse Mercator
ϕ	--	porosity

INTRODUCTION

Taken and adapted from MMS published report MMS 89-0007

The Exxon Lydonia Canyon (LC) Block 133 No. 1 well was the first industry wildcat well drilled in Georges Bank Basin. Spudded on July 24, 1981, the well is about halfway between the Continental Offshore Stratigraphic Test (COST) G-1 and G-2 wells. It is about 21 miles east-southeast of the COST No. G-1 well. The Exxon LC Block 133 No. 1 well was drilled by a semisubmersible rig in 225 feet of water on the continental shelf about 110 miles east-southeast of Nantucket Island and 35 miles from the shelf edge.

Exxon's primary drilling target was a possible patch reef at a depth of approximately 12,600 feet of expected Middle Jurassic (Callovian) age. Drilling results revealed that the reef was actually a 1,120-foot thick interval of igneous rock interbedded with limestone and minor amounts of sandstone. Hurtubise and others (1987) divided this igneous sequence into an upper, 740-foot thick extrusive unit and a lower, 250-foot thick intrusive unit. The COST No. G-2 well penetrated a similar Middle Jurassic limestone containing up to 5 percent volcaniclastic fragments, mostly green and gray tuff, between 11,720 and 11,900 feet (Amato and Simonis, eds, 1980). There were no significant hydrocarbon shows in the Exxon LC Block 133 No.1 well. Four conventional cores (three recovered) and 158 sidewall cores (72 recovered) were attempted. The single drill stem test recovered only water. Petrophysical and geochemical tests indicate that those depths with sufficient reservoir quality (above 12,630 feet) do not have sufficient maturity to generate hydrocarbons. Rocks below 12,600 feet show poor reservoir quality, and kerogen types indicate the probability of only gas.

This report relies on geologic and geophysical data provided to the Minerals Management Service (MMS) by Exxon Company, U.S.A. (Exxon) according to Outer Continental Shelf (OCS) regulations and lease stipulations. The data were released to the public after the LC Block 133 lease No. OCS-A-0170 was relinquished on December 30, 1982. Interpretations of the data contained in this report are those of MMS, unless otherwise stated, and may differ from those of Exxon. Depths are measured from kelly bushing unless otherwise indicated.

The information contained herein is taken from MMS OCS Report MMS 89-0007, published in 1989 and now out of print. No attempt has been made to provide more recent geologic, geochemical, or geophysical interpretations or data, published or unpublished, since the initial report was issued.

This report is initially released on the MMS Internet site **http://www.gomr.mms.gov**, and, together with the other Georges Bank well reports, on a single compact disk (CD). At a later date, additional technical data, including well "electric" logs will be added to the CD.

OPERATIONAL SUMMARY

Taken and adapted from K. U. Siddiqui, MMS published report MMS 89-0007

The Exxon Lydonia Canyon (LC) Block 133 No. 1 well (figures 1 and 2) was drilled by the North Star Drilling Company's *Alaskan Star* semisubmersible drilling rig for Exxon Company, U.S.A. The well was spudded on July 24, 1981 in 225 feet of water. Daily drilling progress is shown for the well in figure 3, and well statistics are presented in table 1. The primary geologic objective was a possible Middle Jurassic (Callovian) patch reef at approximately 12,600 feet.

Five strings of casing were set in the well (figure 4). The 30-inch casing was set to 550 feet with 700 sacks of cement; the 16-inch casing was set to 993 feet with 1,625 sacks of cement; the 13 3/8-inch casing was set to 4,100 feet with 1,200 sacks of cement; the 9 5/8-inch casing was set to 11,754 feet with 1,150 sacks of cement; the 7-inch casing was set to 14,050 feet with 615 sacks of cement. Class H cement was used for all casings.

Lignosulfonate, freshwater, and seawater muds with an average weight of 9.3 pounds per gallon (ppg) were used as drilling fluids to a depth of 1,050 feet. The mud weight was raised to 9.4 ppg at a depth of 3,833 feet and to 9.8 ppg at 10,878 feet. Mud weight reached 11.3 ppg at 13,525 feet and remained at that weight to the total depth of 14,118 feet. Mud viscosity averaged 52 seconds, fluctuating between 41 and 68 seconds, in the first 1,050 feet and averaged about 48 seconds for the remainder of the well. Mud pH averaged 11.1 with minor fluctuation for the entire well. Chloride concentrations began at 450 parts per million (ppm), increased to 5,800 ppm at 12,578 feet, and dropped to 2,600 ppm at TD.

Abandonment procedures are also shown in figure 4. The 7-inch casing was perforated at 12,392 to 12,408 feet and 12,418 to 12,430 feet and a retainer was set at 12,275 feet. A plug was set from 12,225 to 12,586 feet with 50 sacks of cement and was tested at a pressure of 2,500 pounds psi for 15 minutes. The 7-inch casing was cut at 4,249 feet, and the second plug was set between 4,125 and 4,400 feet with 75 sacks of cement and tested at a pressure of 1,000 psi for 15 minutes. The 9 5/8-inch casing was perforated from 3,898 to 3,900 feet, a retainer set at 3,840 feet, and a 150-sack plug was set at 3,780 to 4,334 (annular) feet and tested at a pressure of 1,000 psi for 15 minutes. The 9 5/8-inch casing was cut at 1,150 feet. A 150-sack plug was set from 1,025 to 1,300 feet. The 13 3/8-inch casing was perforated at 796 to 798 feet, a retainer was set at 716 feet, and a 200-sack plug was set from 716 to 1,197 (annular) feet and tested at a pressure of 1,000 psi for 15 minutes. The 13 3/8-inch casing was cut at 558 feet. The 16-inch casing was cut at 335 feet, and the 30-inch casing was cut at 327 feet. The surface plug was set at 420 to 710 feet with 275 sacks of cement and pressure tested.

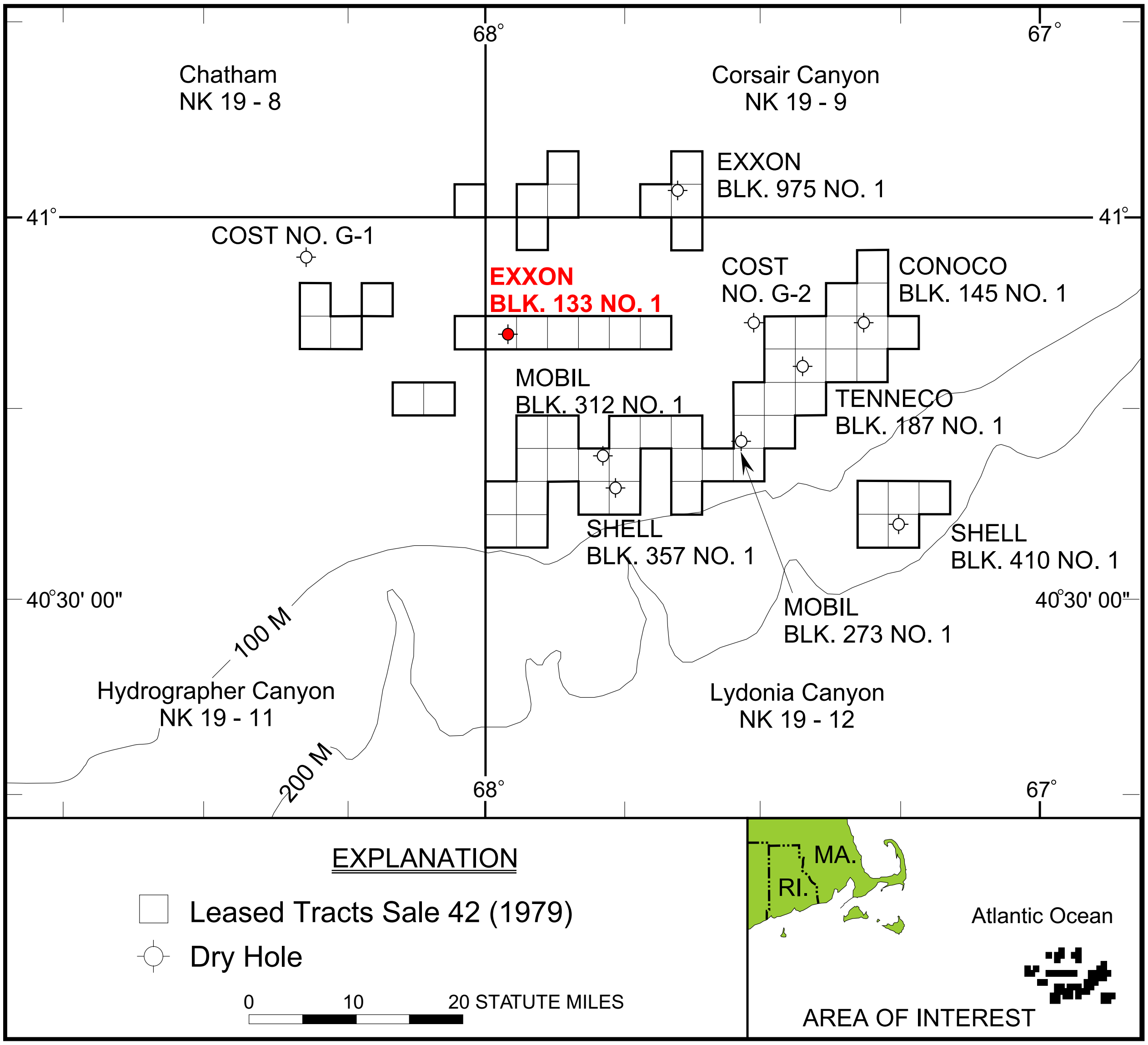

Figure 1. Map of the North Atlantic offshore area showing well locations. The Exxon Lydonia Canyon Block 133 No. 1 well is highlighted in red.. Bathymetry is in meters.

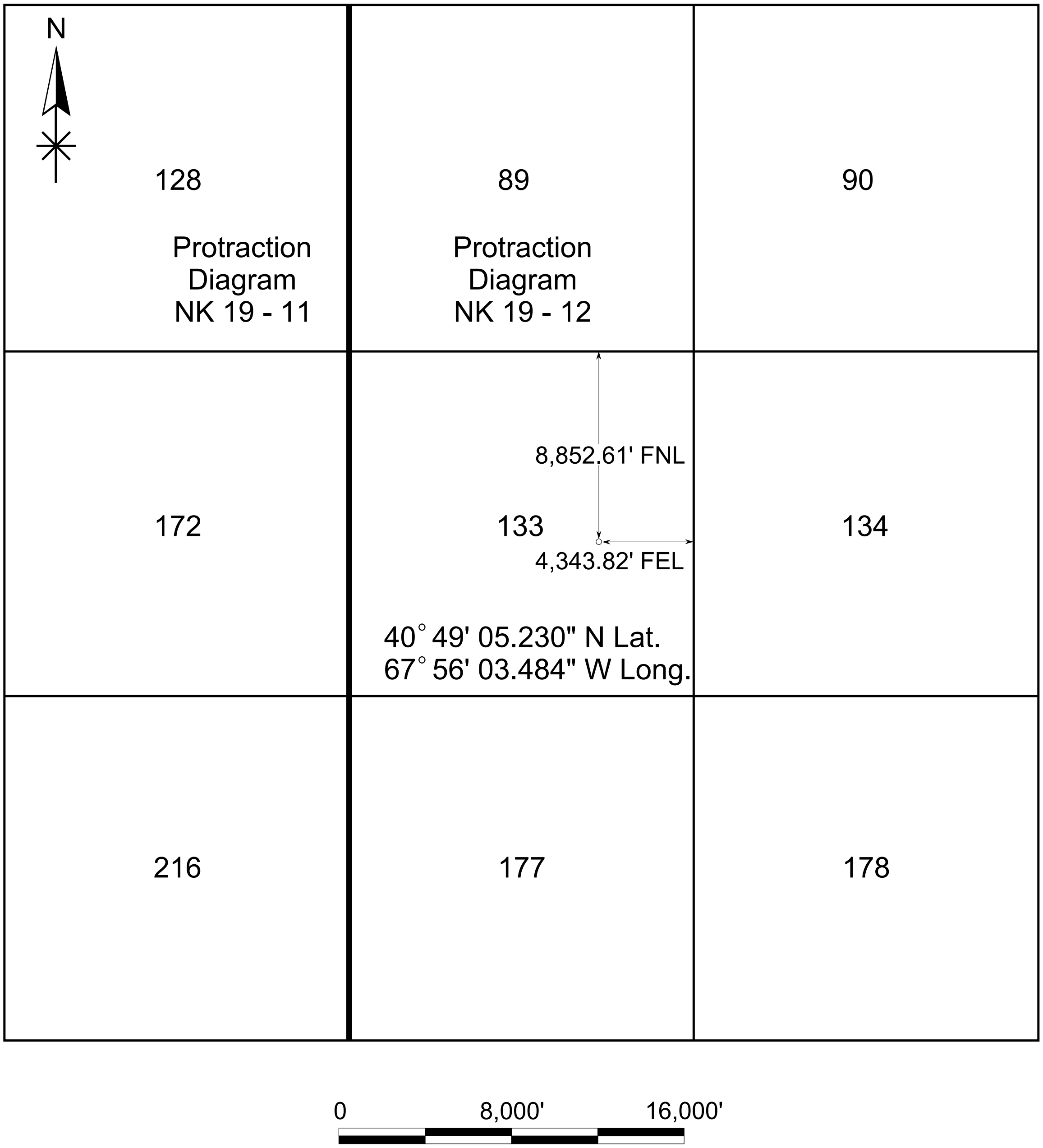

Figure 2. Location plat of the Exxon Block 133 No. 1 well on the OCS Lydonia Canyon NK 19-12 protraction diagram..

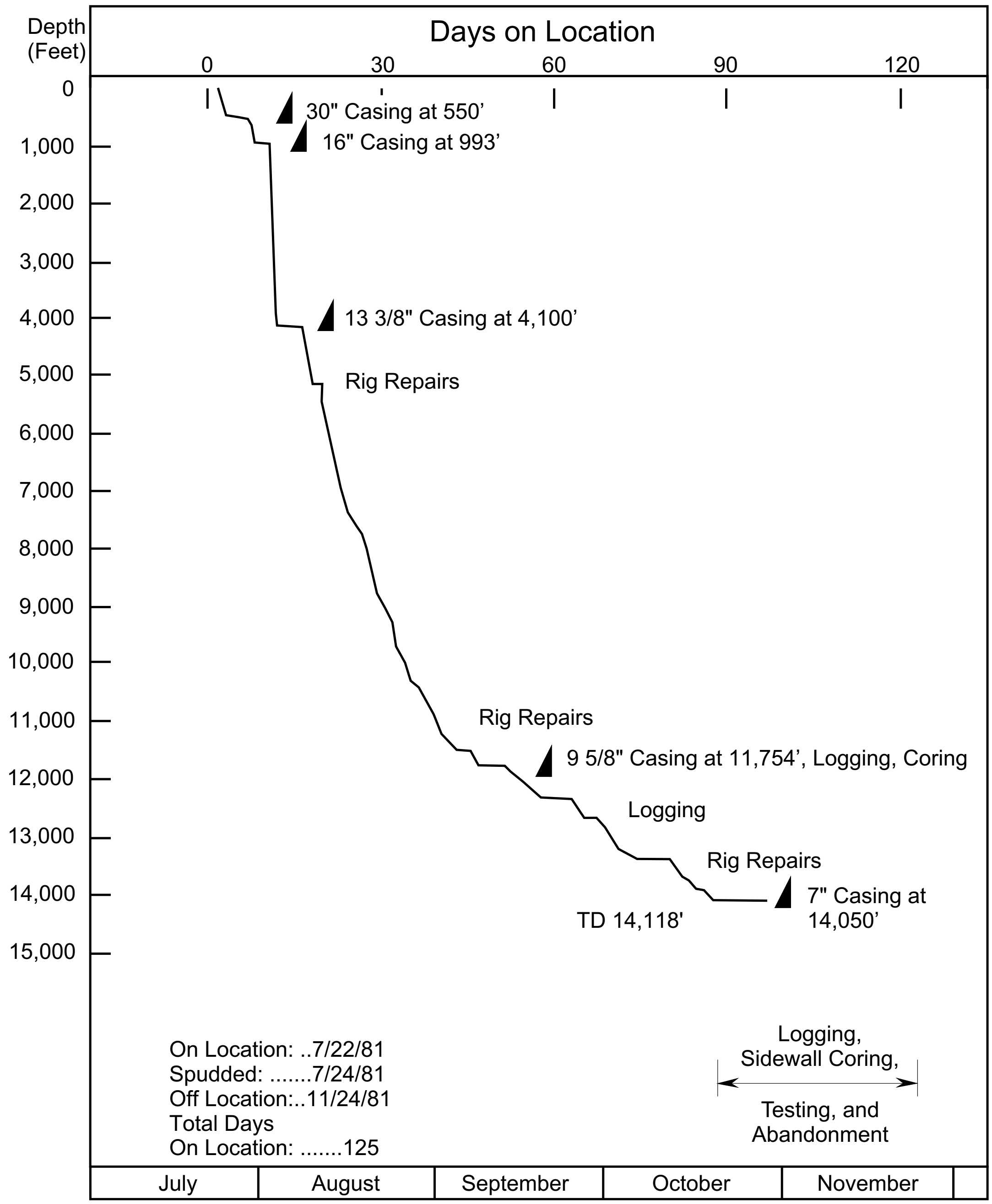

Figure 3. Daily drilling progress for the Exxon Lydonia Canyon Block 133 No. 1 well.

Table 1. Well statistics

Well Identification:	API #61-040-00002 Lease No. OCS-A-0170
Surface location:	Lydonia Canyon NK 19-12 Block 133 8,852.61' FNL 4,343.82' FEL Latitude: 40° 49' 05.230" N Longitude: 67° 56' 03.484" W UTM coordinates: X = 589,876.00m Y = 4,518,901.72m
Bottomhole location:	167.8 feet N and 129.1 feet E of surface location
Proposed total depth:	15,500 feet
True vertical depth:	14,110 feet
Measured depth:	14,118 feet
Kelly bushing elevation:	85 feet
Water depth:	225 feet
Spud date:	July 24, 1981
Reached TD:	October 20,1981
Off location:	November 24, 1981
Final well status:	Plugged and abandoned

Note: All depths indicated in this report are measured from the kelly bushing, unless otherwise indicated. Mean sea level is the datum for the water depth.

The blowout preventer and guide base were pulled, the *Alaskan Star* moved off location on November 24, 1981, and a post-abandonment, seafloor site survey was performed by John Chance and Associates.

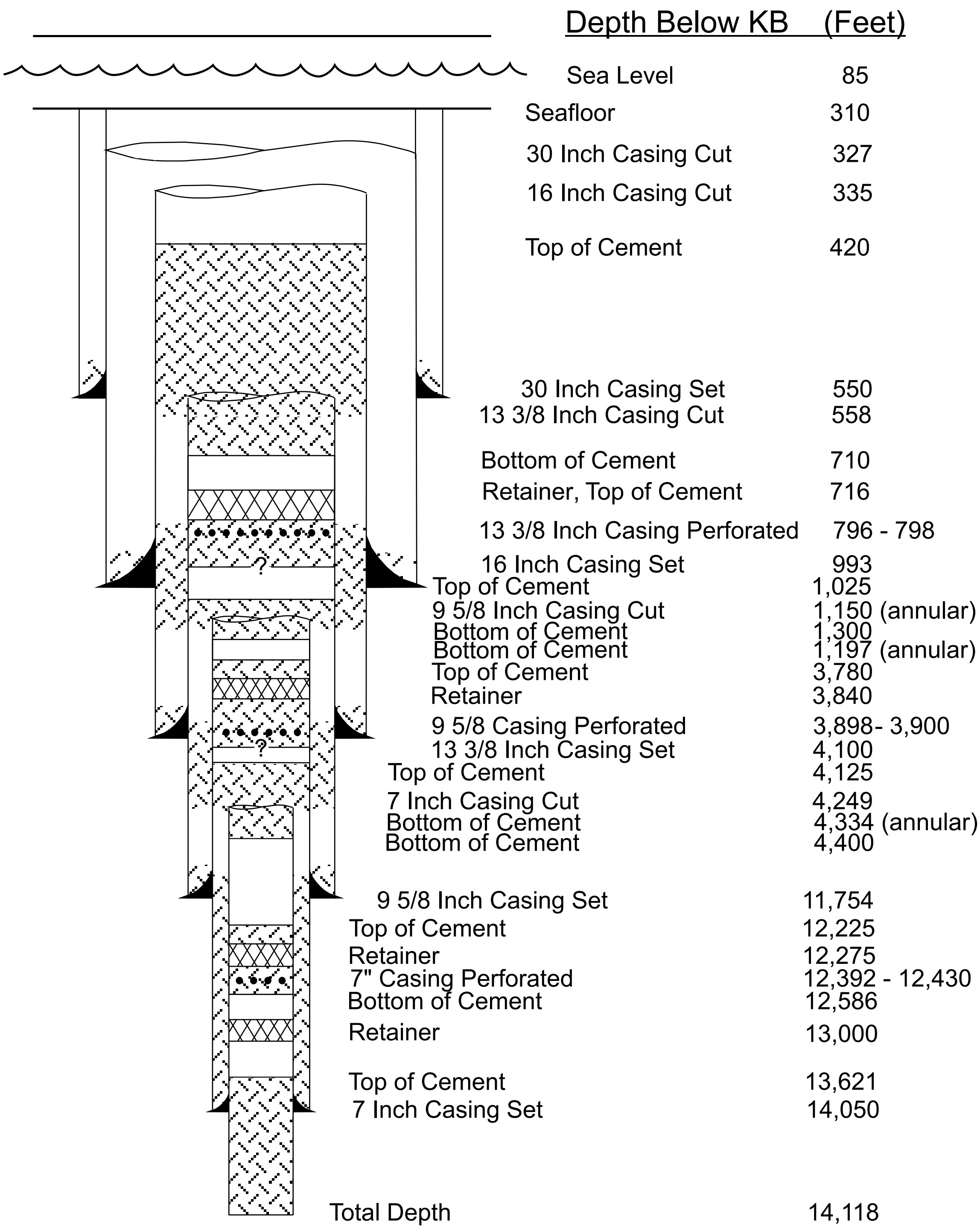

Figure 4. Casing and abandonment diagram for the Exxon Lydonia Canyon Block 133 No. 1 well.

WELL VELOCITY PROFILE

Taken and adapted from A. O. Tanner, MMS published report MMS 89-0007

Velocity surveys of the Exxon LC Block 133 No. 1 well were conducted by Seismograph Service Corporation (Birdwell Division) and Schlumberger, Ltd. In addition to a sonic log, Schlumberger ran a velocity checkshot survey between 8,917 and 13,551 feet, whereas Birdwell conducted a velocity checkshot between 4,817 and 11,657 feet. The checkshot data, together with that for the other nine wells drilled on Georges Bank, were given by MMS to Velocity Databank, Inc. at their request after all leases had been relinquished or had expired. Velocity Databank calculated interval, average, and RMS velocities, plotted time-depth curves, and tabulated the data. The Birdwell data were used for the Exxon LC 133 No. 1 well. Table 2 presents well depth, two-way travel time, and the calculated velocities. Figures 5 and 6 show interval velocity, average velocity, and RMS velocity plotted against depth and against two-way travel time. These depths are relative to sea level.

A lithology column is also shown in figure 5, and velocity intervals are given in table 3. The first checkshot at 227 feet is near the seafloor and yields water-column velocities. From 4,817 feet (the first checkshot below mudline) to 11,657 feet (the deepest data), six intervals are identified based on changes in relative interval velocities.

Interval I This interval contains the first two data points, including the water column and sediment to 5,000 feet. The low to moderate velocities increase with depth, reflecting the progression from water to unconsolidated sediment to lithified siliciclastic rock. The velocity increase is also a consequence of greater rock densities with increasing depth, an effect that continues through subsequent intervals. This interval is Lower Cretaceous to Tertiary.

Interval II This interval is identified on the basis of intermediate interval velocities reflecting limestone, sandstone, shale, and siltstone. The interval is Lower Cretaceous.

Interval III This interval is identified on the basis of intermediate interval velocities that reflect increasing finer grained siliciclastic sediments and less limestone with depth. The interval is Middle and Upper Jurassic.

Interval IV This interval is identified on the basis of an increase in interval velocities. The lithologic description (and mud log show interbedded siliciclastics and calcareous siliciclastics throughout the interval. The interval is Middle Jurassic.

Interval V This interval is identified on the basis of high velocities, averaging 17,280 feet per second, which correlate with limestone and siliciclastic interbeds. This interval is Middle Jurassic.

Interval VI The final interval includes a single reading, the deepest in the well at 11,657 feet, with an extremely high interval velocity of 40,002 feet per second. This velocity is probably in error, being in excess of that for any crustal rock type.

Table 2. Velocity data

Depth (Feet)	Two-way Travel Time (Seconds)	Interval Velocity (Feet/Sec.)	Average Velocity (Feet/Sec.)	RMS Velocity (Feet/Sec.)
227	0.090	5,044	5,044	5,044
4,817	1.340	7,343	7,189	7,211
5,217	1.426	9,302	7,316	7,354
5,417	1.466	10,000	7,390	7,439
5,617	1.498	12,499	7,499	7,582
5,817	1.534	11,111	7,584	7,684
6,017	1.572	10,526	7,655	7,765
6,217	1.612	10,000	7,713	7,828
6,417	1.646	11,764	7,797	7,929
6,617	1.674	14,285	7,905	8,076
7,017	1.744	11,428	8,047	8,237
7,217	1.774	13,333	8,136	8,349
7,417	1.804	13,333	8,222	8,456
7,817	1.874	11,428	8,342	8,586
8,017	1.902	14,285	8,430	8,697
8,217	1.934	12,499	8,497	8,773
8,417	1.966	12,500	8,562	8,846
8,617	2.002	11,111	8,608	8,892
8,817	2.030	14,285	8,686	8,988
9,017	2.054	16,666	8,779	9,116
9,217	2.090	11,111	8,820	9,154
9,417	2.114	16,666	8,909	9,273
9,617	2.148	11,764	8,954	9,318
9,817	2.174	15,384	9,031	9,413
10,017	2.208	11,764	9,073	9,454
10,217	2.230	18,181	9,163	9,579
10,417	2.256	15,384	9,234	9,666
10,617	2.288	12,499	9,280	9,711
10,817	2.318	13,333	9,333	9,766
11,017	2.344	15,384	9,400	9,846
11,217	2.362	22,222	9,497	9,999
11,417	2.392	13,333	9,545	10,047
11,617	2.414	18,181	9,624	10,151
11,657	2.416	40,002	9,649	10,212

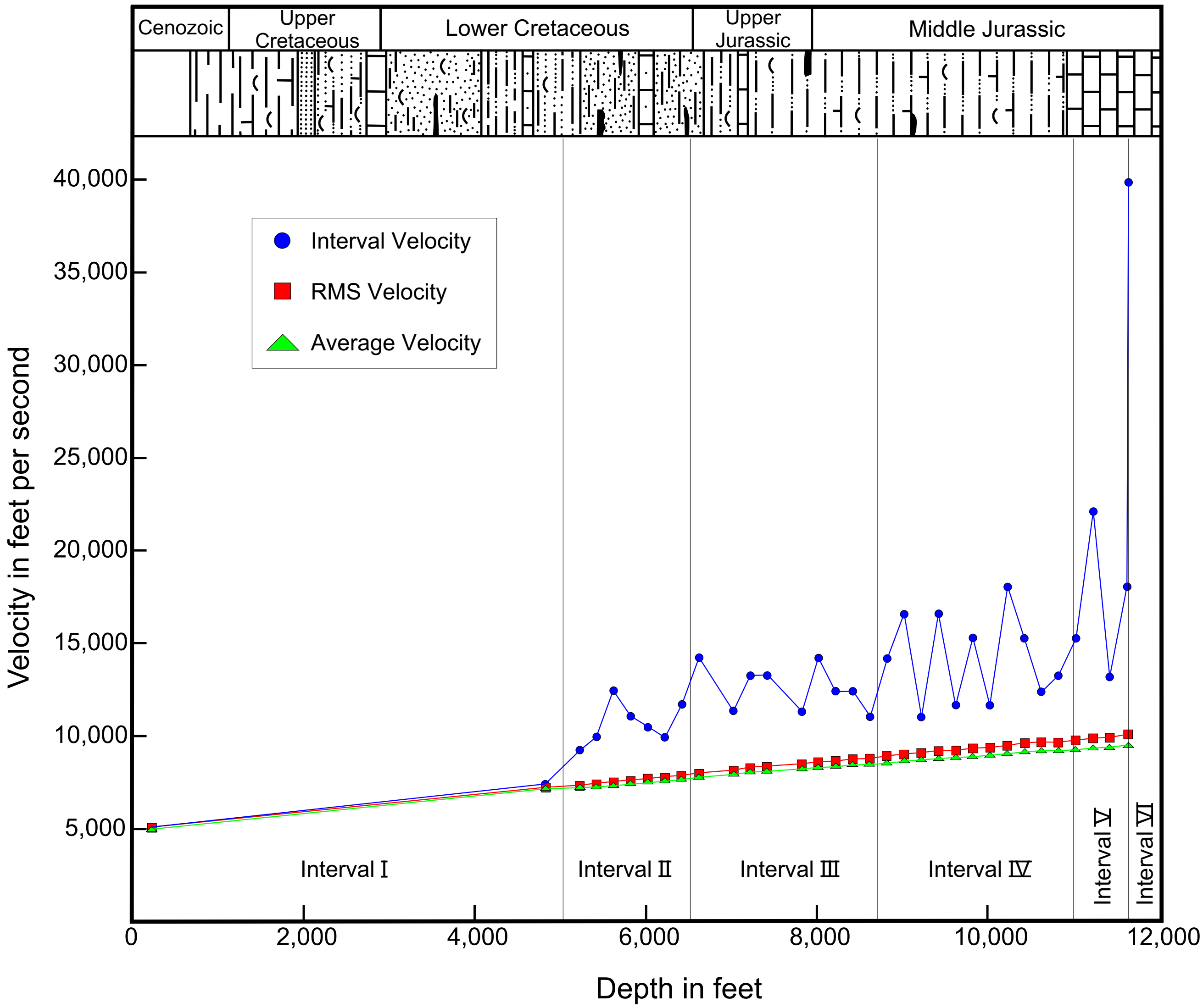

Figure 5. Well velocity profile for the Exxon Lydonia Canyon Block 133 No. 1 well, plotted against depth, with biostratigraphic ages and generalized lithologies. Intervals are explained in text.

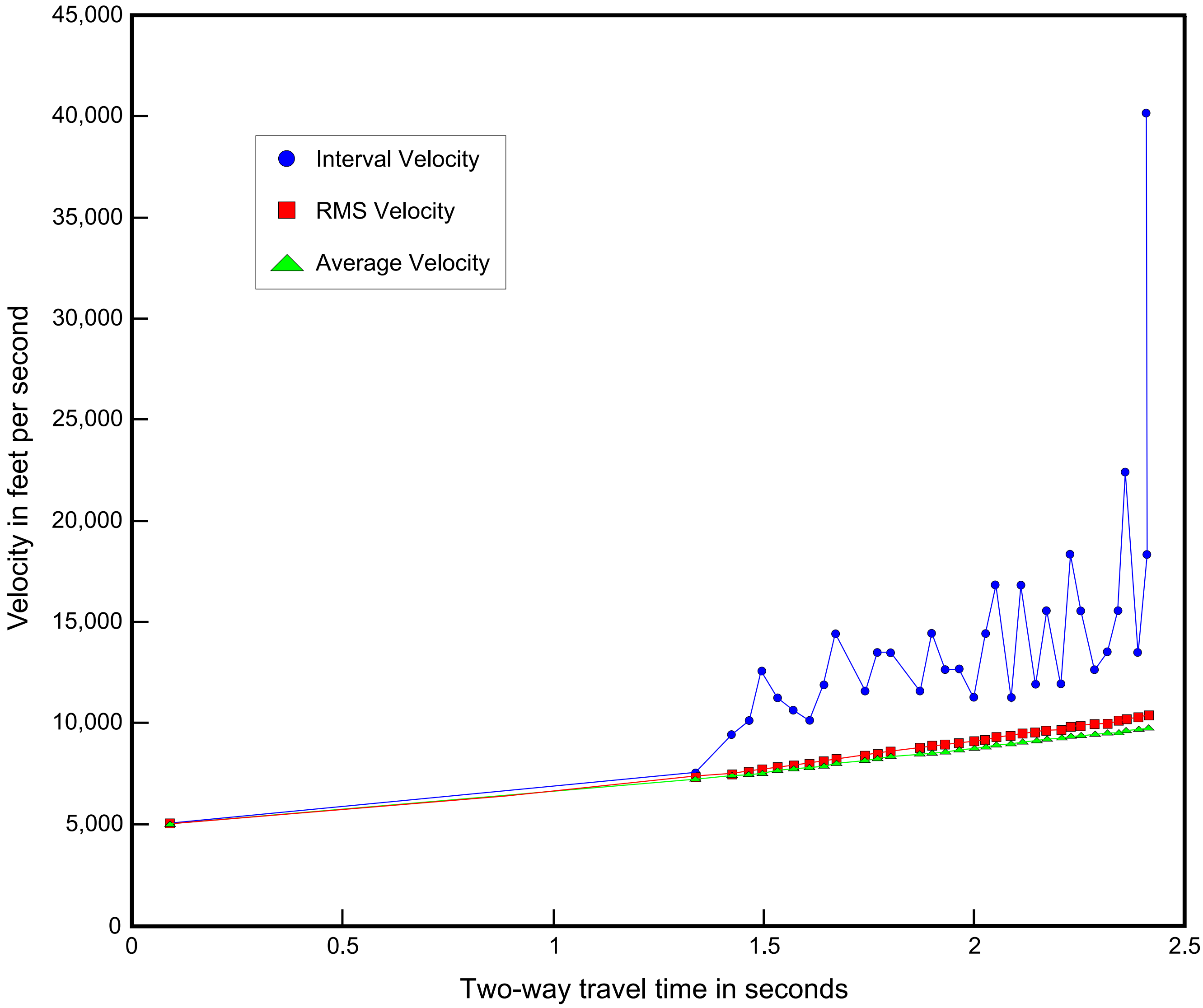

Figure 6. Well velocity profile for the Exxon Lydonia Canyon Block 133 No. 1 well, plotted against two-way travel time.

Table 3. Well velocity intervals

Interval	Depth Range (feet)	Interval Velocity Range (feet/second)	Average Interval Velocity (feet/second)
I	0- 5,000	5,044- 7,343	6,194
II	5,000- 6,500	9,302-12,499	10,743
III	6,500- 8,700	11,111-14,285	12,689
IV	8,700-11,000	11,111-18,181	14,276
V	11,000-11,630	13,333-22,222	17,280
VI	11,630-11,657	40,002	40,002

Well cuttings indicate limestone at 11,657 feet; igneous rock fragments were not recognized until about 12,500 feet. At about 65 microseconds per foot, the sonic log does not indicate an anomalously high velocity that corresponds to the deepest checkshot velocity. Altogether, well logs are consistent with interbedded carbonates and siliciclastics below 11,000 feet. Interval VI is Middle Jurassic.

LITHOLOGIC INTERPRETATION

Taken and adapted from A. C. Giordano, MMS published report MMS 89-0007

These descriptions are based on well cutting samples, collected at 10-foot intervals from 630 to 14,118 feet in the Exxon LC Block 133 No. 1 well. Sample quality ranged from fair to good, depending on the amount of cavings and the degree of washing. Additional lithologic control was provided by the physical formation "mud" log, 72 sidewall core analyses, descriptions of three conventional cores, and examination of chips from the conventional cores. Depths of lithologic boundaries are adjusted with reference to "electric" and "mud" logs. All depths are from kelly bushing. Rocks penetrated are divided into gross lithologic-stratigraphic units, and a lithologic column appears in figure 7.

LITHOLOGIC DESCRIPTIONS

From 630 to 1,180 feet, the section consists of gray to gray-green, soft, slightly silty claystone. A glauconitic clay, between 1,180 and 1,280 feet, marks an unconformity between the Paleocene and oxidized Upper Cretaceous (Maestrichtian) rocks.

Between 1,280 and 1,950 feet, the section consists of light-gray to gray-green, slightly calcareous claystone and argillaceous siltstone. Glauconite, fragments of megafossils, foraminifera, carbonaceous plant fragments, fine mica, and pyrite also occur.

Between 1,950 and 2,720 feet, the section consists of unconsolidated coarse quartz grains and granules, interbedded with light-gray, slightly calcareous silty claystone and clayey siltstone. Fossil fragments and inertinite occur within the clays. The dominant lithology between 2,720 and 2,960 feet is light-gray to white, microcrystalline, fossiliferous limestone that is mottled in places.

Between 2,960 and 3,800 feet the section consists of sand, shell fragments, glauconite pellets, mica flakes, thin streaks of lignite, and calcite cement. The sand is quartz, fine to granular, subangular to subrounded, and unconsolidated. Carbonaceous, dark-gray shales also occur. From 3,800 to 4,880 feet, a red-to-gray mudstone is interbedded with the sandstone. The sandstone in this mudstone sequence is similar to that of the overlying sandy section, but also includes gray, fine-to-medium-grained, muddy, friable wackestone.

The section from 4,880 to 6,610 feet consists of limestone, sandstone, siltstone, mudstone, and shale. The upper portion of this section, from 4,880 to 5,600 feet, is cryptocrystalline, sandy limestone and glauconitic, pyritic shale and siltstone interbedded with glauconitic and fossiliferous, calcareous sandstone. From 5,600 to 6,610 feet, thick-bedded sandstone with shale and coal interbeds forms the lower portion of this section. Much of the lower sandstone is poorly consolidated and very coarse to medium in texture. Present also is very fine-to-medium grained, subangular, moderately well-sorted sandstone tightly cemented by calcite and silica. Between 5,520 and

Figure 7. Columnar chart of the lithology, biostratigraphy, and paleobathymetry of the Exxon Lydonia Canyon Block 133 No. 1 well. Lithologic interpretations from examination of cuttings; lithologic breaks picked from well logs. Within columns, depths refer to uppermost occurrence of index fossils listed in Biostratigraphy chapter . Stage tops based on paleontology. Biostratigraphy and bathymetric interpretations become less reliable with increasing depth.

6,120 feet, numerous thin beds of coal occur in dark, carbonaceous shale, brown-gray shale, and light-gray mudstone. From 6,350 to 6,610 feet, the sandstone is interbedded with limestones and shale.

The section from 6,610 to 7,250 feet consists of sandstone, shale, and limestone. The sandstone beds are sparse and thin. The shales are gray to dark gray, silty, and calcareous. The limestone is light gray to tan, cryptocrystalline, oolitic, fossiliferous, and argillaceous. Contact with the underlying sandy unit is gradational.

The section between 7,250 and 10,850 feet contains sandstone, red and gray shale, and streaks of coal. Most of the sandstone is white, fine to medium grained, subangular, moderately to well sorted, and friable to tightly cemented by calcite. Muscovite, biotite, and chlorite are common. Some sandstone beds in the lower part of the sequence are iron stained. The shales from 7,250 to 8,960 feet are gray to dark gray, silty, and variably calcareous. Red shales appear below 8,960 feet.

The section from 10,850 to 12,390 feet consists mainly of oolitic packstone. Present also are fine-grained, well-sorted sandstones, dark-gray, argillaceous shales, and gray mudstones.

The interval from 12,390 to 13,130 feet is primarily an extrusive unit consisting of volcaniclastic rock and basalt flows with minor limestone interbeds (Hurtubise and others, 1987). Sandstone interbeds also occur in the uppermost part of this unit. Below 12,580 feet, tuff comprises as much as 5 percent of each sample and persists in trace amounts to 13,260 feet. The tuff is green and gray, vesicular, devitrified glass and occurs as inclusions.

From 13,130 to 14,118 feet (TD) the section consists of tight, cryptocrystalline limestones, within which an intrusive basalt occurs from 13,260 to 13,510 feet. The basalt is very fine grained with a dark gray matrix containing scattered crystals of quartz, olivine, calcite, and chlorite. Fractures are filled with veins of soft serpentine. A radiometric date of 136 million years indicates an Early Cretaceous age (Hurtubise and others, 1987).

POTENTIAL RESERVOIR ROCKS

Sidewall core analysis for the sandstones above 6,610 feet shows a porosity range from 17 to 25 percent and permeability as high as 68 millidarcies (md). Most samples are calcite cemented. Cementation appears to have occurred relatively early, before significant compaction. Primary porosity is preserved in many of the better sorted sands.

Reservoir quality varies from 6,610 to 10,850 feet. No porosity is evident from 6,650 to 8,080 feet. From 8,080 to 9,830 feet, visually estimated porosity is from 15 to 23 percent. From 9,900 to 10,850 feet, it is 8 to 14 percent. Silty sandstones and shales are either compacted or tightly cemented with dolomite or calcite.

From 10,850 to 14,118 feet, visual porosity ranges from negligible to 15 percent. Sandstone in sidewall cores from 12,000 to 14,007 feet has indicated porosities of 4.5 to 17 percent but very low permeabilities, ranging from <0.1 to 3.4 md. The limestone beds are very tight, and no significant secondary porosity is evident. Siltstones are tightly cemented with silica and calcite. Three conventional cores recovered from intervals between 12,250 and 13,491 feet contain cryptocrystalline limestone, shales, and the intrusive basalt, none with significant porosity.

BIOSTRATIGRAPHY

Taken and adapted from H. L. Cousminer, W. E. Steinkraus, and L. E. Bielak, MMS published report MMS 89-0007

Two factors limit the reliability of paleontologic data from exploration wells. (1) Analyses are made from drill cuttings that are often heavily contaminated by cavings from higher in the drill hole. For this reason, only “tops,” or the uppermost (last) appearances of species, are recorded. (2) Reworked, older fossil assemblages and individual specimens are commonly reincorporated in detrital sedimentary rocks. These fossils must be recognized so those intervals are not dated older than they really are. In addition, in U.S. offshore Atlantic wells, biostratigraphic control is poor in pre-Late Jurassic strata. Calcareous nannofossils and foraminifera are sparse. Palynomorphs are more common, but their biostratigraphic distribution is not fully documented with reference to the European type-stage localities.

Microfossils were examined from 630 to 14,118 feet (TD) (figure 7) in the Exxon LC Block 133 No. 1 well. The analysis included 128 palynomorph slides prepared from composite 90-foot intervals from the entire range of well sample depths; 266 nannofossil slides representing 30-foot intervals from 730 to 8,620 feet; and 74 foraminiferal slides from 30-foot intervals from 730 to 3,000 feet. The interpreted ages range from Miocene to Bajocian. An unconformity was observed at 1,180 feet.

Planktonic foraminiferal age markers are identified in only three Late Cretaceous samples. Nannofossil markers range in age from Middle Jurassic (Callovian) to Late Cretaceous (Campanian) age. Palynomorphs (dinocysts, spores, and pollen) range in age from Early Jurassic (Sinemurian-Hettangian) to Miocene. However, all palynomorphs older than Middle Jurassic in age are considered to have been reworked in the section. After completion of the initial study, which was based solely on cuttings samples, core samples from 12,258 to 12,326 feet were received from the operator. Palynologic analysis of an additional 20 slides representing nine sample splits within this cored interval indicates it to be of Middle Jurassic age (Bajocian). Environments of deposition ranged from nonmarine to inner shelf.

CENOZOIC

TERTIARY

Miocene (730-820 feet)

This interval contains palynomorph species of Carya, Lycopodium, Osmunda, Quercus, Piceapollenites, Pinuspollenites, Polypodium,, and Sphagnum. The absence of Compositae, Chenopodiaceae, and Gramineae indicates a probable mid-early Miocene age. The environment of deposition is inner shelf (0-50 feet).

Indeterminate (820-1,100 feet)

Samples from 820 to 1,100 feet are barren. The environment of deposition is probably nonmarine.

Early Eocene-Paleocene (1,100-1,180 feet)

The highest occurrence of Alnipollenites sp. and Laevigatosporites haardtii at 1,100 feet indicates an early Eocene age (Bebout, 1980). The highest occurrence of Stereisporites and Sapotaceoidaepollenites at 1,100 feet indicates Paleocene. Therefore, this interval is considered to be Paleocene to early Eocene in age. Other palynomorphs present include Alnipollenites, Laevigatosporites haardtii, Momipites, Nymphaceae, Sapotaceoidaepollenites, Stereisporites, and Tetrasporites. No nannofossils or foraminifera are present. The environment of deposition is nonmarine.

MESOZOIC

CRETACEOUS

Late Cretaceous

Maestrichtian (1,180-1,340 feet)

The interval from 1,180 to 1,280 feet is barren. However, organic residues match those from below 1,280 feet; therefore, the interval is probably of Late Cretaceous age. The highest occurrence of Lejeunia koslowskii at 1,280 feet indicates a Maestrichtian age (Gorka, 1963; Kjellstrom, 1973). The planktonic foraminifera Globotruncana arca and G. marginata found in this interval support a Maestrictian age. The environment of deposition is inner shelf. The sudden change from nonmarine to inner shelf at 1,180 feet indicates an unconformity.

Campanian (1,340-1,460 feet)

The nannofossil Gartnerago obliquum and the pollen Retitricolpites sp. "M" Wolfe indicate a Campanian age. According to Bebout (1981), the latter does not range above Campanian in the Mid-Atlantic OCS. The environment of deposition is inner shelf.

Santonian (1,460-1,820 feet)

The highest occurrence of the nannofossil Marthasterites furcatus at 1,460 feet marks the top of the Santonian. The environment of deposition is inner shelf but the presence of Pediastrum sp. may indicate nearshore brackish conditions.

Coniacian (1,820-2,090 feet)

The highest occurrence of Globotruncana renzi at 1,820 feet indicates a Coniacian age. The environment of deposition is inner shelf.

Turonian (2,090-2,660 feet)

The Turonian nannofossil Corollithion achylosum was identified at 2,090 feet. The environment of deposition is inner shelf.

Cenomanian (2,660-2,900 feet)

The highest occurrence of the planktonic foraminifera Rotalipora appenninica and R. cushmani at 2,660 feet and the nannofossil Corollithion signum "A" at 2,720 feet indicate a Cenomanian age for this interval. Abundant dinocysts from 2,720 feet to 2,810 feet indicate the upper Cenomanian Cleistrosphaeridium huguonioti subzone of Clarke and Verdier (1967). The environment of deposition is inner shelf.

Early Cretaceous

Albian (2,900 to 3,800 feet)

The highest occurrence of the dinocysts Apteodinium maculatum and Astrocysta cretacea at 2,900 feet mark the top of the Albian. Pediastrum sp., possibly indicating brackish nearshore conditions, is also present at 3,260 feet. Trilobosporites apiverrucatus, from 3,270 feet, does not range above the Albian (Bebout, 1980). The environment is nonmarine to inner shelf for the lower part of the interval.

Aptian (3,800 to 4,880 feet)

Abundant dinocysts at 3,800 feet indicate the Cyclonephelium attadalicum zone, which is confined to the early Aptian on the Scotian Shelf (Williams, 1977). The nannofossils Nannoconus globulus (4,580 feet) and N. wassalli (4,820 feet), as well as Bebout's (1981) spore species 110 (4,700 feet), support an Aptian age for this interval. The spore does not range above the Aptian in the Mid-Atlantic OCS. The environment of deposition is inner to middle shelf.

Barremian (4,880-5,450 feet)

The Tenua anaphrissa subzone at 4,880 feet (Williams, 1977) indicates a Barremian age in the Scotian Shelf-Grand Banks region. Other dinocyst species present that do not range into the Aptian are Muderongia simplex, Polystephanephorus sarjeantii, and Pseudoceratium pelliferum (Williams, 1977). The environment of deposition is inner to middle shelf, shallowing to inner shelf at approximately 5,000 feet.

Hauterivian-Vananginian (5,450-6,340 feet)

The highest occurrence of Bebout's Trilobosporites 132 and 133 indicate a Hauterivian or Vananginian age for the interval from 5,450 to 5,980 feet. These forms do not range above the Hauterivian in the Mid-Atlantic Outer Continental Shelf. The environment of deposition is inner shelf for the upper part of the interval, shallowing progressively to nonmarine in the lower part of the section.

Berriasian (6,340-6,520? feet)

The dinocysts Chlamydophorella sp. "A" Davey, Phoberocysta neocomica, Kleithriasphaeridium sp. "A" Davey, and Bebout's spores 139 and 140 are present in this interval. In England and northwest Europe, Kleithriasphaeridium sp. "A" Davey does not range above the Ryazanian (Berriasian) Speeton Clay (Davey, 1979). Bebout (1981) reports that the spore types 139 and 140 do not range above the Berriasian in the Mid-Atlantic OCS. The environment of deposition is nonmarine.

JURASSIC

Late Jurassic

Tithonian (6,520?-6,970 feet)

A barren zone, 6,520 to 6,610 feet, is oxidized and appears to match the immediately underlying interval. Ctenidodinium panneum present below 6,610 feet indicates a Tithonian age. The Scotian Shelf Ctenidodinium panneum Zone is provisionally dated as Tithonian (Williams, 1977). Davey (1979) restricted the upper range of this species to lower Tithonian in northwest Europe. The environment of deposition is inner shelf.

Kimmeridgian (6,970-7,330 feet)

The Kimmeridgian top is marked by an abundant dinocyst assemblage including Gonyaulacysta longicornis, G. cladophora, G. mamillifera, G. sp. "H" (Gitmez and Sarjeant, 1972), and Hexagonifera (Senoniasphaera) jurassica. The environment of deposition is inner shelf, shallowing to marginal marine deeper in the section.

Oxfordian (7,330-7,870 feet)

The highest occurrence of Adnatosphaeridium aemulum and Surculosphaeridium vestitum at 7,330 feet indicates the Oxfordian age. The nannofossil species Watznaueria reinhardti and Stephanolithion bigoti were recovered at 7,600 feet. S. vestitum does not range above Oxfordian (Sarjeant, 1979). A. aemulum and S. vestitum do not range above the Oxfordian (Bujak and Williams, 1977). In the Scotian Shelf-Grand Banks region S. bigoti ranges from Oxfordian to lower Kimmeridgian. The environment of deposition is inner shelf.

Middle Jurassic

Callovian (7,870-8,590 feet)
The highest occurrence of Stephanolithion spectiosumoctum at 7,870 feet marks the Callovian. The dinocysts Valensiella ovulum and Gonyaulacysta aldorfensis both have their highest occurrences in this interval and do not range above the Callovian in the Scotian Shelf-Grand Banks region (Bujak and Williams, 1977). Abundant also in this interval are the longer-ranging Adnatosphaeridium sp., A. aemulum, Ctenidodinium ornatum, and Sentusidinium spp. The environment of deposition is inner shelf, shallowing to marginal marine in the lower 200 feet.

Bathonian (8,590-9,760 feet)

The highest occurrence of the dinocyst species Gonyaulacysta filapicata at 8,590 feet marks the top of the Bathonian (Bujak and Williams, 1977). Other dinocyst species present include Gonyaulacysta aldorfensis, Sentusidinium spp., Lithodinia jurassica, and Adnatosphaerieium callyeri, all of which range above the Bathonian. Present also are Ctenidodinium continuum, C. ornatum, C. pachydermum, Leptodinium spp., and Vanensiella spp. Gocht (1970) described a similar assemblage from the type Bathonian of northwest Germany. A barren interval from 9,480 to 9,760 feet contains detrital minerals and tracheal detritus, probably representing a regressive facies. The environment of deposition is marginal marine to nonmarine.

Bajocian (9,760-13,130 feet)

The highest occurrence of sparse Mancodinium semitabulatum and Mendicodinium reticulatum mark the top of the Bajocian. Present also is abundant

Gonyaulacysta filapicata from 9,760 to 10,570 feet. Although numerous palynomorphs that are restricted to Liassic age in several Scotian Shelf-Grand Banks wells (Bujak and Williams, 1977) are present in cuttings from 10,570 to 12,326 feet, these are all considered to be reworked. Core samples from 12,258 to 12,326 feet contain abundant Middle Jurassic (Bathonian-Bajocian) dinoflagellate species, including Adnatosphaeridium callyeri, Ctenidodinium spp., Dichatogonyaulax aff. staruomatos, Gonyaulacysta pectinigera, and Mancodinium semitabulatum. These indicate that the older (Hettangian-Pleinsbachian) species present in both the cuttings and core material are reworked elements. Such species include Corollina meyeriana, Convolutispora klukiforma, Cycadopites subgranulosus, Kraeuselisporites reissingeri, and Verrucosisporites cheneyi (Bujak and Williams, 1977). According to Hurtubise and others (1987), these palynomorphs represent erosional detritus accumulated during Liassic subaerial exposure and recycled during the subsequent Middle Jurassic marine transgression. The environment of deposition is nonmarine in the upper 500 feet, deepening to inner shelf from approximately 10,200 to 11,500 feet. From 11,500 to approximately 12,600 feet the environment of deposition is marginal marine to inner shelf, becoming nonmarine to 13,130 feet.

Barren (13,130-14,118 feet)

Samples examined from 13,130 to 14,118 feet were barren of fossil material. The environment of deposition was probably nonmarine.

FORMATION EVALUATION

Taken from R. R. Nichols, MMS published report MMS 89-0007

Schlumberger Ltd. ran the following geophysical "electric" logs in the Exxon LC Block 133 No. 1 well to provide information for stratigraphic correlation and for evaluation of formation fluids, porosity, and lithology:

Table 4. Well logs

Log Type	Depth Interval (feet) below KB
DISFL (dual induction-spherically focused log)	997-14,118
GRS (gamma ray-sonic log)	997-14,118
GRN (gamma ray-neutron log)	367-13,659
CNL/FDC (compensated neutron log/compensated formation density log)	4,101-14,118
FDC (compensated formation density log)	4,101-14,118
FIL (fracture identification log)	11,739-14,114

Exploration Logging, Inc. provided a formation evaluation log "mud log" that included a rate of penetration curve, sample descriptions, and a graphic presentation of hydrocarbon shows encountered (550 to 14,115 feet).

The electric logs, together with the mud log and other available data, were analyzed in detail to determine the thickness of potential reservoirs, average porosities, and feet of hydrocarbons present. Reservoir rocks with porosities less than 5 percent were disregarded. A combination of logs was used in the analysis, but a detailed lithologic and reservoir property determination from samples, conventional cores, and sidewall cores, in addition to full consideration of any test results, is necessary to confirm the estimates shown in table 5.

Table 5. Well log interpretation summary

Depth Interval (feet)	Potential Reservoir[1] (feet)	Average Porosity (%)	SW (%)	Feet of Hydrocarbon
1,953-2,038	84	35	NC[2]	
2,744-4,260	797	35	NC	
4,782-6,668	1,058	23-33	NC	
6,668-8,030	---	---	NC	
8,030-8,974	340	15-24	NC	
9,082-9,867	205	12-18	NC	
9,992-10,130	69	15	NC	
10,220-10,256	34	14	NC	
10,550-10,574	22	9	NC	

Continued

Table 5. Well log interpretation summary--*continued*

Depth Interval (feet)	Potential Reservoir[1] (feet)	Average Porosity (%)	SW (%)	Feet of Hydrocarbon
10,718-10,732	14	13	NC	
10,778-10,788	10	10	NC	
10,834-10,850	16	9	NC	
10,962-11,148	80	8-15	NC	
12,398-12,411	8	23	25	---[3]
12,424-12,434	8	24	26	---[3]
13,464-13,504	37	12[4]	10[4]	---[4]
13,504-14,118	---	---	NC	

[1]Generally in beds > 10 feet thick and ϕ> 5%
[2]NC--not calculated
[3]Drill stem test of the 12,392-12,408 and 12,418-12,430 foot intervals recovered 564 bbl of water.
[4]From sidewall core analysis at 13,492 and 13,498 feet, ϕ= 12%, k = 1 md. Caliper shows severe washout in this zone with corresponding decrease in reliability of electric log responses. No mud log shows were present in this zone. Zone was conventionally cored.

A summary of the sidewall core analysis is shown in table 6.

Table 6. Sidewall core analysis summary

Depth Interval (feet)	Lithology	Porosity Range (%)	Permeability Range (md)
4,785-6,600	Sandstone	17-25	0.2-68
12,000-12,300	Sandstone	4.5-16	<0.1-3.4
12,300-12,800	Sandstone	4.8-17	<0.1-3.0
13,492-14,007	Sandstone	10-13	0.5-1.0

Four conventional cores were taken. Core 3 was not recovered. Lithologic descriptions for cores 1, 2, and 4 were provided by Exxon, but petrophysical core analysis was not available for comparison to specific electric log responses. The conventional core properties are described as follows in table 7.

Table 7. Conventional core analysis summary

Core No.	Depth Interval (feet)	Lithology	Porosity	Permeability
1	12,250-12,270	Limestone	Tight	Negligible
2	12,272-12,326	Limestone	Tight	Negligible
3[a]	13,481-13,486	---	---	---
4	13,488-13,491	Diabase	---	---

[a]Not recovered

Table 8 summarizes shows of hydrocarbons encountered in this well, and table 9 lists all hydrocarbon shows. Two drilling breaks were encountered in the interval from 12,400 to 12,435 feet and the mud-logging unit detected significant

Table 8. Drillstem test results

Test No.	Interval Tested (feet)[1]	Length of Test (hours)	Final Flow Pressure (psi)	Final Shut-in Pressure (psi)	Results/ Recovery
DST-1	12,392-12,430	12.5	8,744	6,770	564 bbl of water, no gas or liquid hydrocarbon, no hydrogen sulfide

[1]Drilling breaks occurred in the interval 12,400-12,435 feet with mud log total gas readings increasing from zero to 95 units.

amounts of gas. The mud log total gas readings increased from a background of zero to a high of 95 units (methane only). Well log interpretation in the zone of interest indicates eight feet of potential reservoir between 12,398 and 12,411 feet with an average porosity of 23 percent and a water saturation of 25 percent. An additional eight feet of potential reservoir exists between 12,424 and 12,434 feet with an average porosity of 24 percent and a water saturation of 26 percent. Density log porosity exceeding the sonic log porosity indicates the probability of secondary porosity in the zone of interest. Characteristic crossover responses of the CNL and FDC curves suggest the presence of gas in this interval, supporting the mud log response.

Sidewall core porosity values for the two intervals in the zone of interest range from 4.8 to 16.3 percent. However, permeability is extremely low, ranging from less than 0.1 to 3.0 md. The sidewall cores were analyzed, but no significant shows of hydrocarbons were reported. Both intervals within the zone of interest were tested on November 13, 1981. A drill stem test with perforations at 12,392 to 12,408 feet and at 12,418 to 12,430 feet recovered 564 barrels of water but no gas or liquid hydrocarbons (tables 8 and 9).

Table 9. Hydrocarbon show summary

Depth (Feet)	Drilling Break	Sample Description (Mud Log)	Hot wire (units)	Chromatograph	Sidewall cores[a]	Well Log Interpretation[b]	Comments	Test
6,950	-	Siltstone with yellow mineral flu., White-yellow cut	-	-	-	-	-	-
11,000	-	Oolitic LS, and SS, dull yellow flu., dead oil?, no cut	-	-	-	-	-	-
12,150	3 - 25	SS, firm, abundant brown stain, yellow flu., no cut	-	malfunction	-	-	-	-
12,400 - 12,410	9 - 16	LS, micrite, dull yellow - dark green flu., no cut	-	C_1	ϕ = 4.8-15.2% k =<0.1-1.8 md	ϕ = 23% Sw = 25%	Characteristic crossover response of CNL / FDC, indicating presence of gas	DST of 12,392 - 12,408 and 12,418 - 12,430 ft recovered 564 bbl of water
14,428 - 14,433	9 - 25	LS, micrite, dull yellow - dark green flu., no cut	-	C_1	ϕ = 6.1-16.3% k =<0.1-3.0 md	ϕ = 24% Sw = 26%		

[a] Sonic ϕ compares favorably with sidewall core ϕ.
[b] Density ϕ used for Sw calculation.

GEOTHERMAL GRADIENT

Figure 8 shows bottomhole temperatures for five logging runs in the Exxon LC Block 133 No. 1 well plotted against depth. A temperature of 60 ^{O}F is assumed at the seafloor at an indicated depth of 310 feet (225-foot water depth plus 85-foot kelly bushing elevation). Shown also is a straight-line graph between the seafloor and total-depth temperatures in order to represent an overall geothermal gradient for the well, which is 1.18 degrees Fahrenheit per 100 feet. Calculated geothermal gradients for all Georges Bank wells range from 1.06 to 1.40 degrees Fahrenheit per 100 feet.

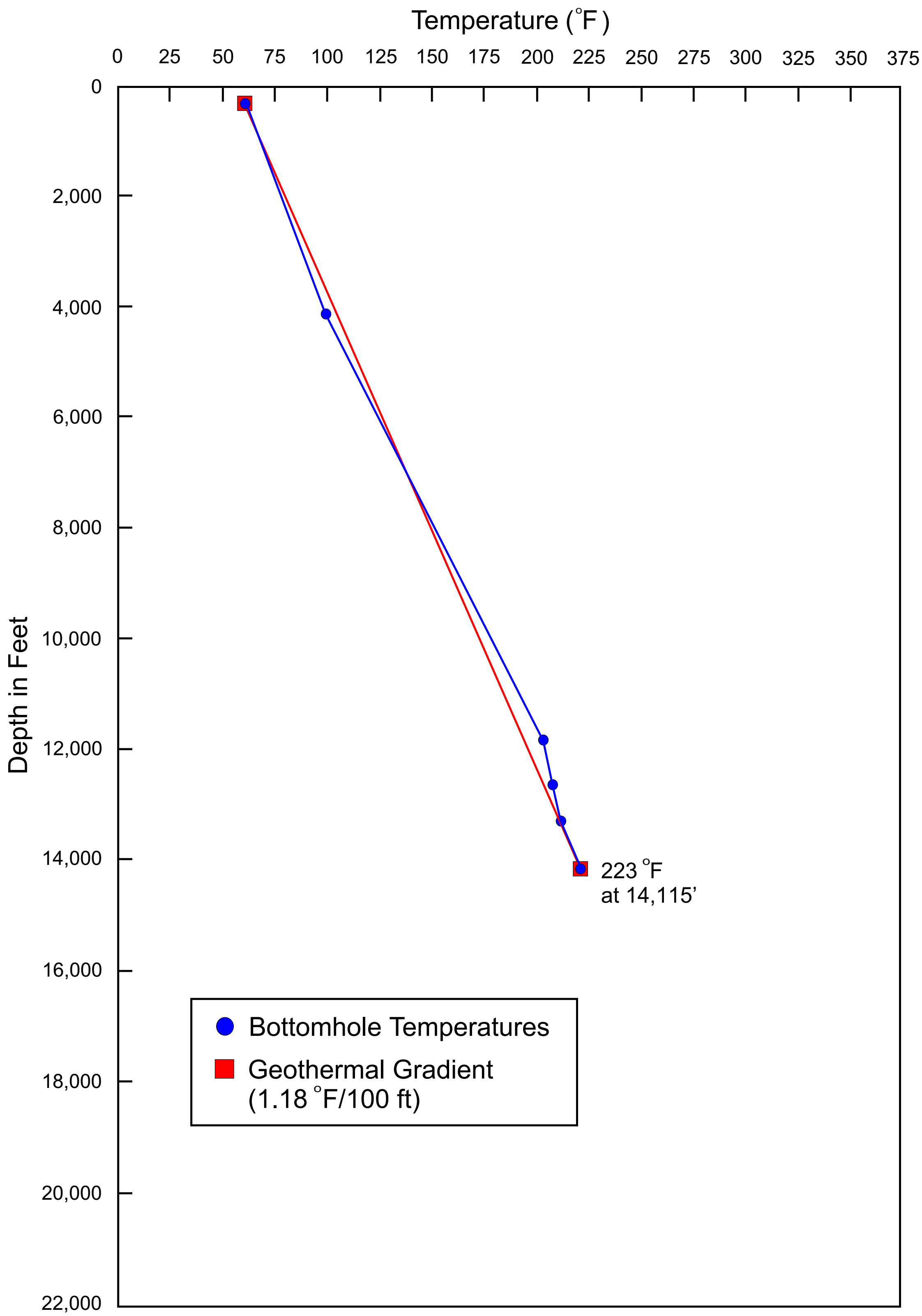

Figure 8. Well temperatures and geothermal gradient for the Exxon Lydonia Canyon Block 133 No. 1 well. Well temperatures from bottomhole temperatures of logging runs. Geothermal gradient based on bottomhole temperature of deepest logging run.

KEROGEN ANALYSIS

Taken and adapted from C. E. Fry, H. L. Cousminer, and J. K. Filer, MMS published report MMS 89-0007

Kerogen type and thermal rank were determined by microscopic examination of kerogen slides and palynology slides made from cuttings samples from the Exxon LC Block 133 No. 1 well. In this analysis, organic material is classified as one of four major types: algal-amorphous, organic material of marine origin, either recognizable algae or the unstructured remains of algal material; herbaceous, leafy portions of plants, including spores and pollen; woody, plant detritus with a lignified, ribbed structure; coaly, black opaque material, thought to be chemically inert. Visual estimates are made for the percentage of each type relative to the total abundance of kerogen contained in each of the slides. Algal material is generally considered the best source for oil; more structured terrestrial kerogen is primarily a gas source.

Thermal maturity of the organic material is estimated by comparing the color of various palynomorphs contained in the kerogen slides to the thermal alteration index (TAI) scale (figure 9) taken from Jones and Edison (1978). The colors displayed by the organic matter are an indication of the degree to which the kerogen has been thermally altered (Staplin, 1969).

Judging thermal maturity using samples from well cuttings must be done with great care to ensure that the material being analyzed is indigenous to the level sampled. Caved or reworked materials will both give false indications of maturity. Oxidation caused by a high-energy environment of deposition also can alter the appearance of the organic material.

KEROGEN TYPE

Cuttings samples are available in the Exxon LC Block 133 No. 1 well below 640 feet, well depth below kelly bushing. Overall in the well, the abundance of coaly and woody kerogens is greater than that of herbaceous and algal kerogens, and algal material is much less abundant than the other three types (figure 10). To about 8,000 feet, the four kinds of kerogen are fairly constant in relative abundance, but below this depth, within the Middle Jurassic, coaly and woody types increase while herbaceous and algal types decrease in abundance. From about 13,000 feet to TD, 14,118 feet, woody and herbaceous abundance increases and coaly abundance decreases. However, within this interval, the herbaceous organic matter is degraded. Within Tertiary through Lower Jurassic rocks, above 8,000 feet, there are three intervals with significant algal kerogen abundance, 640 to 2,090 feet, 3,710 to 5,710 feet, and 6,970 to 7,600 feet. Within these intervals, two samples contained

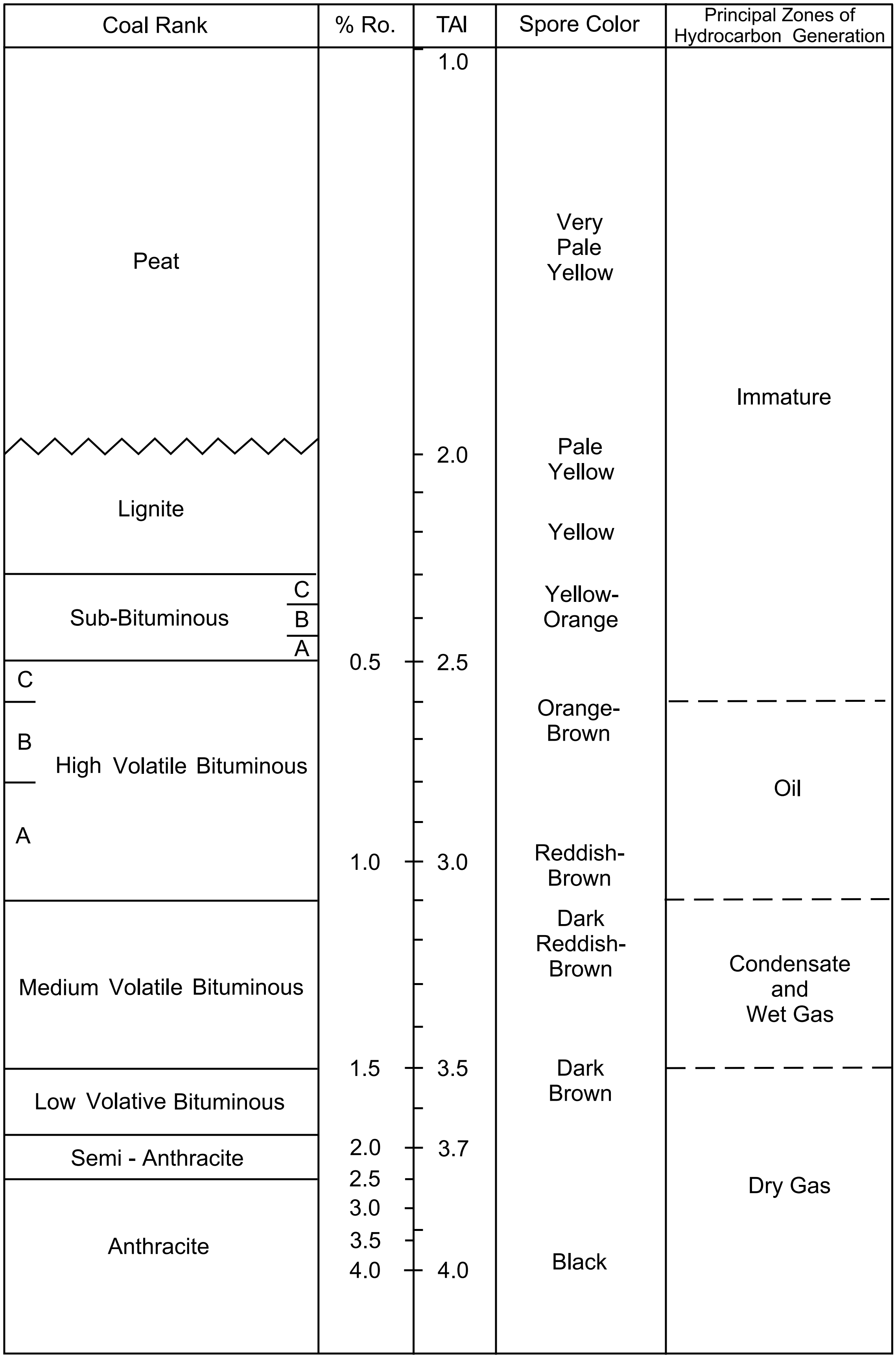

Figure 9. Relationships among coal rank, percent R_o, TAI, spore color, and thermal zones of hydrocarbon generation (after Jones and Edison, 1978).

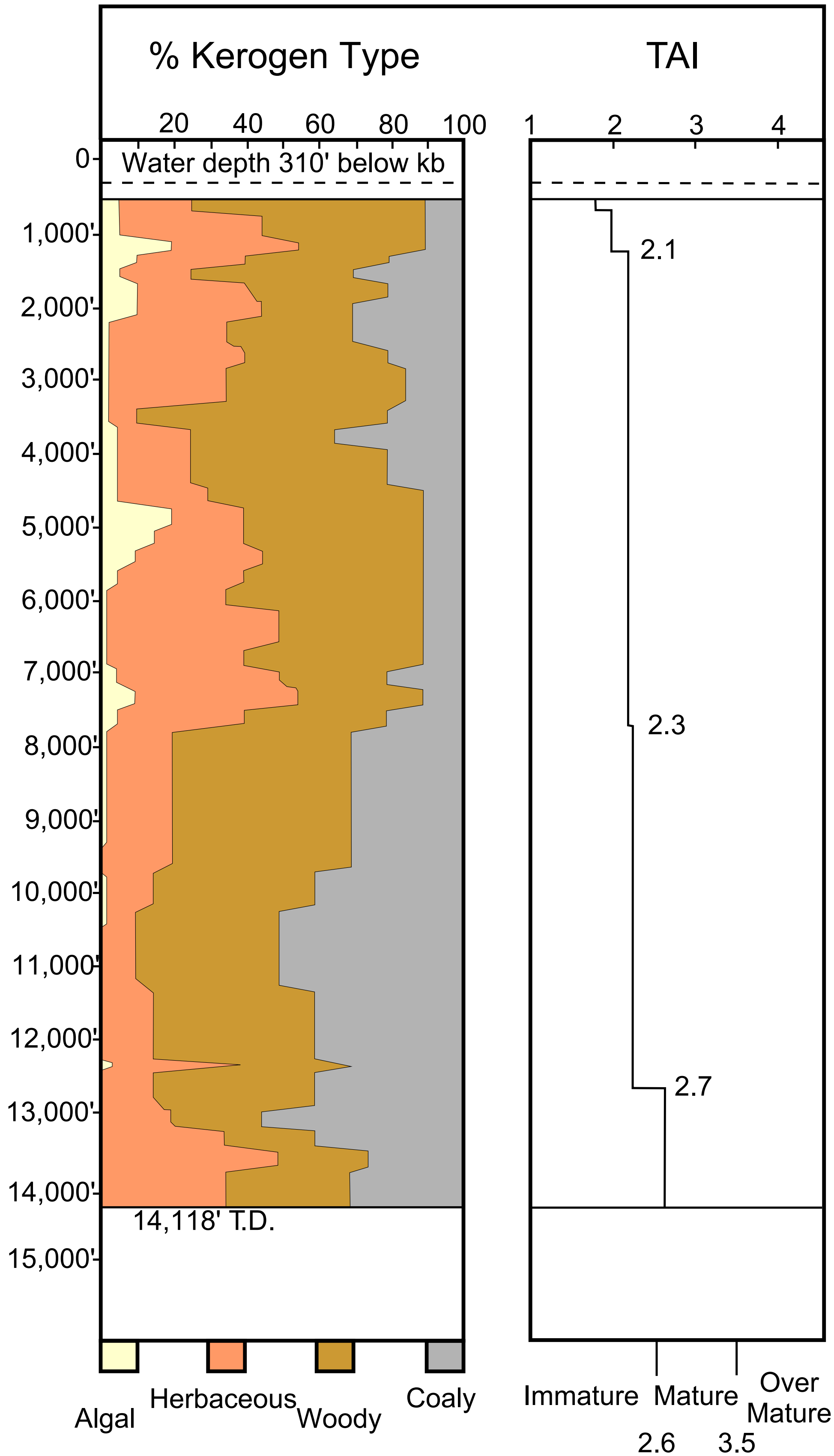

Figure 10. Graph of kerogen types and organic thermal maturity for the Exxon Lydonia Canyon Block 133 No.1 well.

20 percent algal organic matter and most samples contained 10 percent or less.

THERMAL MATURITY

Thermal maturity estimates for hydrocarbon generation, based on palynomorph alteration colors, are presented in figure 10. A thermal alteration index (TAI) value of 2.7 occurs from 12,630 feet to total depth. This level of maturity is only marginally greater than the minimum threshold of 2.6. Shallower sedimentary units are immature for petroleum generation.

CONCLUSIONS

In the Exxon LC Block 133 No. 1 well, sedimentary rock above 12,630 feet is thermally immature for petroleum generation. Within the marginally mature interval below this depth, organic matter is mostly woody and coaly, although herbaceous kerogens increase to about 40 percent from 13,000 feet to total depth at 14,118 feet. However, organic richness is very poor. Figure 11 shows total organic carbon (TOC) analyses results for the well, and TOC below 12,600 feet is less than one percent for all samples. Altogether, the sedimentary section penetrated by this well does not appear to contain potential petroleum source rock.

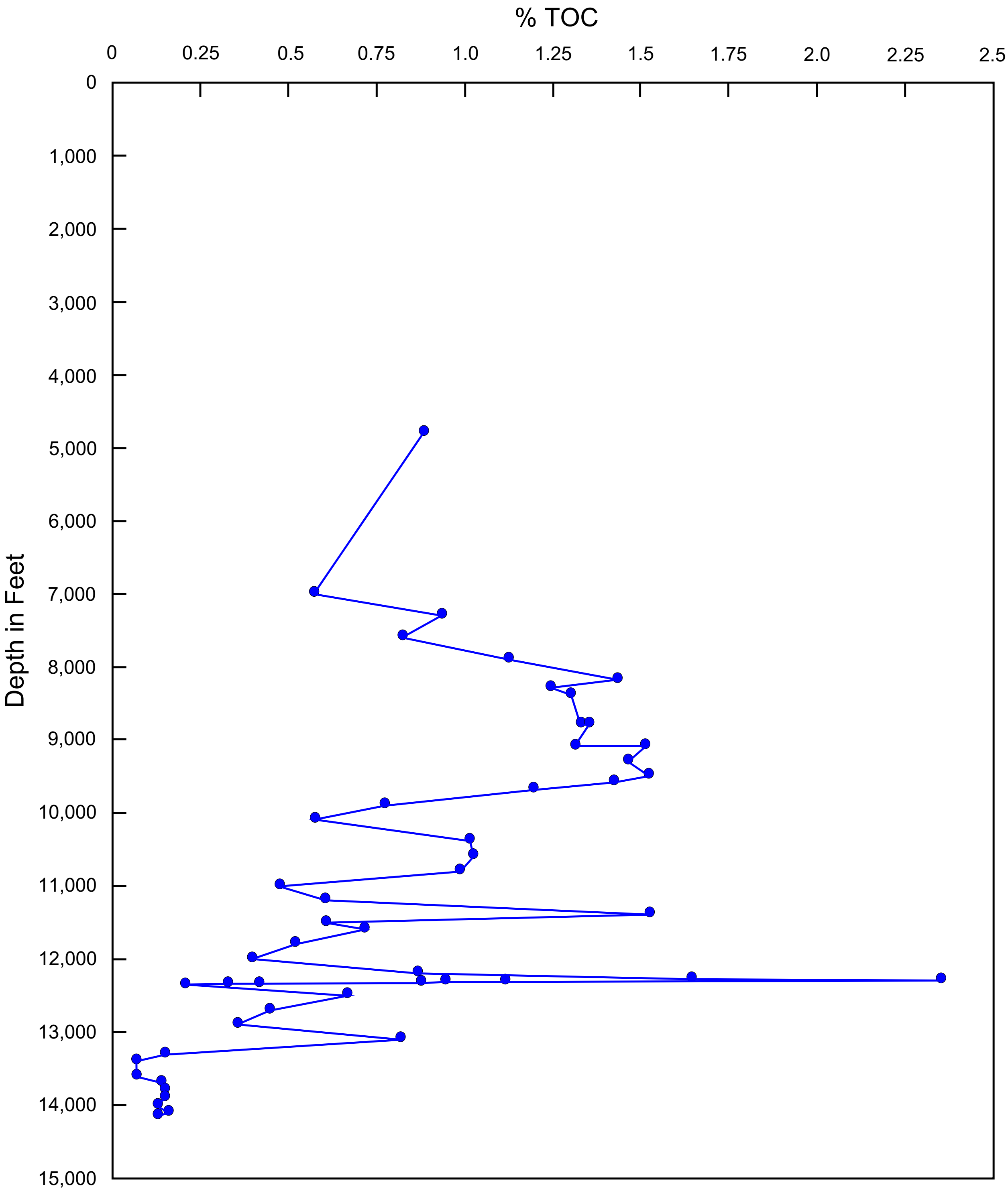

Figure 11. Total organic carbon analysis for the Exxon Lydonia Canyon Block 133 No. 1 well. Data from Exxon.

PETROLEUM GEOCHEMISTRY

Taken and adapted from R. E. Miller, H. L. Cousminer, and C. E. Fry, MMS published report MMS 89-0007

The objective of this section is to assess the petroleum source potential of rocks penetrated by the Exxon LC Block 133 No. 1 well. Low-molecular-weight hydrocarbon analysis, total organic carbon, and thermal pyrolysis data are from Exxon Company, USA, Houston. Petrographic examination of organic residues and palynomorphs, in order to identify kerogen and extent of sedimentary thermal alteration, is reported in the **Kerogen analysis** chapter of this report.

Table 10. Total organic carbon

Depth (ft)	% TOC
4,770	0.88
6,970	0.57
7,270	0.93
7,570	0.82
7,870	1.12
8,170	1.43
8,270	1.24
8,370	1.30
8,770	1.33
8,770	1.35
9,070	1.31
9,070	1.51
9,270	1.46
9,470	1.52
9,570	1.42
9,670	1.19
9,870	0.77
10,070	0.57
10,370	1.01
10,570	1.02
10,770	0.98
10,970	0.47
11,170	0.60
11,370	1.52
11,470	0.60

Depth (ft)	% TOC
11,570	0.71
11,770	0.51
11,970	0.39
12,170	0.86
12,260	1.64
12,269	0.94
12,282	2.35
12,284	1.11
12,296	0.87
12,307	0.32
12,317	0.41
12,325	0.20
12,470	0.66
12,670	0.44
12,870	0.35
13,070	0.81
13,270	0.14
13,370	0.06
13,570	0.06
13,670	0.13
17,770	0.14
13,870	0.14
13,970	0.12
14,070	0.15
14,118	0.12

ORGANIC RICHNESS

Source rock richness of the well is shown in figure 11 and table 10, which illustrate the distribution of total organic carbon (TOC) with depth for 50 well cuttings samples from 4,770 to 14,118 feet (TD).

The Cretaceous section, from 1,180 to 6,520 feet, contains mixed lithologies but is not adequately represented with only one analysis, 0.88 weight percent TOC at 4,770 feet. The Jurassic section, from 6,520 to 13,100 feet, also consists of mixed lithologies and contains 40 TOC values that range from 0.35 to 2.35 and average 0.97 weight percent. Such values are in the poor to good range. Below 13,100 feet, in limestones that are undated but of probable Middle Jurassic age, TOC values decrease significantly and range from 0.06 to 0.14 weight percent. These values are poor. Thermal pyrolysis data, furnished by Exxon, show S_2 values less than one mg/g for all 50 cuttings samples. These values are especially low below 12,400 feet, less than 0.1 mg/g. Low-molecular-weight hydrocarbon analyses, C_1-C_4, submitted by Exxon (figure 12, table 11) show low concentrations for the entire well (256 to 7,390 ppm). The highest concentrations are at shallow depths, above 2,000 feet, owing to biogenic methane. The gas concentrations generally decrease with depth in the lower part of the well, paralleling the total organic carbon and thermal pyrolysis results. Gasoline-range hydrocarbon concentrations are also low for the entire section penetrated by the well, ranging from zero to four ppm (table 11). The TOC, thermal pyrolysis, and low-molecular-weight and gasoline-range hydrocarbon analyses all suggest that the entire sedimentary section is organically too lean to contain significant hydrocarbon source rocks.

KEROGEN TYPES

Types of organic matter present in the well are described in the **Kerogen analysis** chapter of this report. In three intervals the well contains up to 20 percent (of total kerogen) amorphous, algal-appearing material. These intervals are 640 to 2,090 feet, 3,710 to 5,710 feet, and 6,970-7,600 feet. The interval between 8,000 and 13,000 feet contains predominantly woody and coaly kerogens. From 13,000 feet to TD, herbaceous kerogens are in greater abundance, generally about 40 percent, although much of this organic matter has been degraded and is poorly preserved, losing most of its structure.

Thermal pyrolysis analysis by Exxon confirms that hydrogen-poor, woody and, coaly kerogens are the most abundant types of organic matter in this well. The hydrogen index, S_2/TOC, ranged from zero to 143. Values less than 200 suggest the dominance of gas-prone, terrestrially derived woody and coaly organic matter. The predominance of woody and coaly organic matter in this well is similar to the results reported for the COST G-1 and COST G-2 wells at equivalent depths (Miller and others, 1982). The Exxon LC Block 133 No. 1 well is located almost equidistant between the two COST wells.

THERMAL MATURITY

A thermal alteration index (TAI) value of 2.7 was recognized from 12,630 to 14,118 feet (TD) (figure 10). This level of thermal maturity is marginal for petroleum generation. Above 12,630 feet, the stratigraphic section is not thermally mature. Thermal pyrolysis transformation ratios $[S_1/S_1 + S_2)]$ reported by Exxon do not show significant conversion of organic matter to petroleum in any samples for the entire depth of the well. However, with the low S_1 and S_2 values of these organically lean rocks, the transformation ratio is probably not a reliable indicator of thermal maturity, especially below 12,400 feet, where the section is extremely lean, but where the TAI data suggest that the

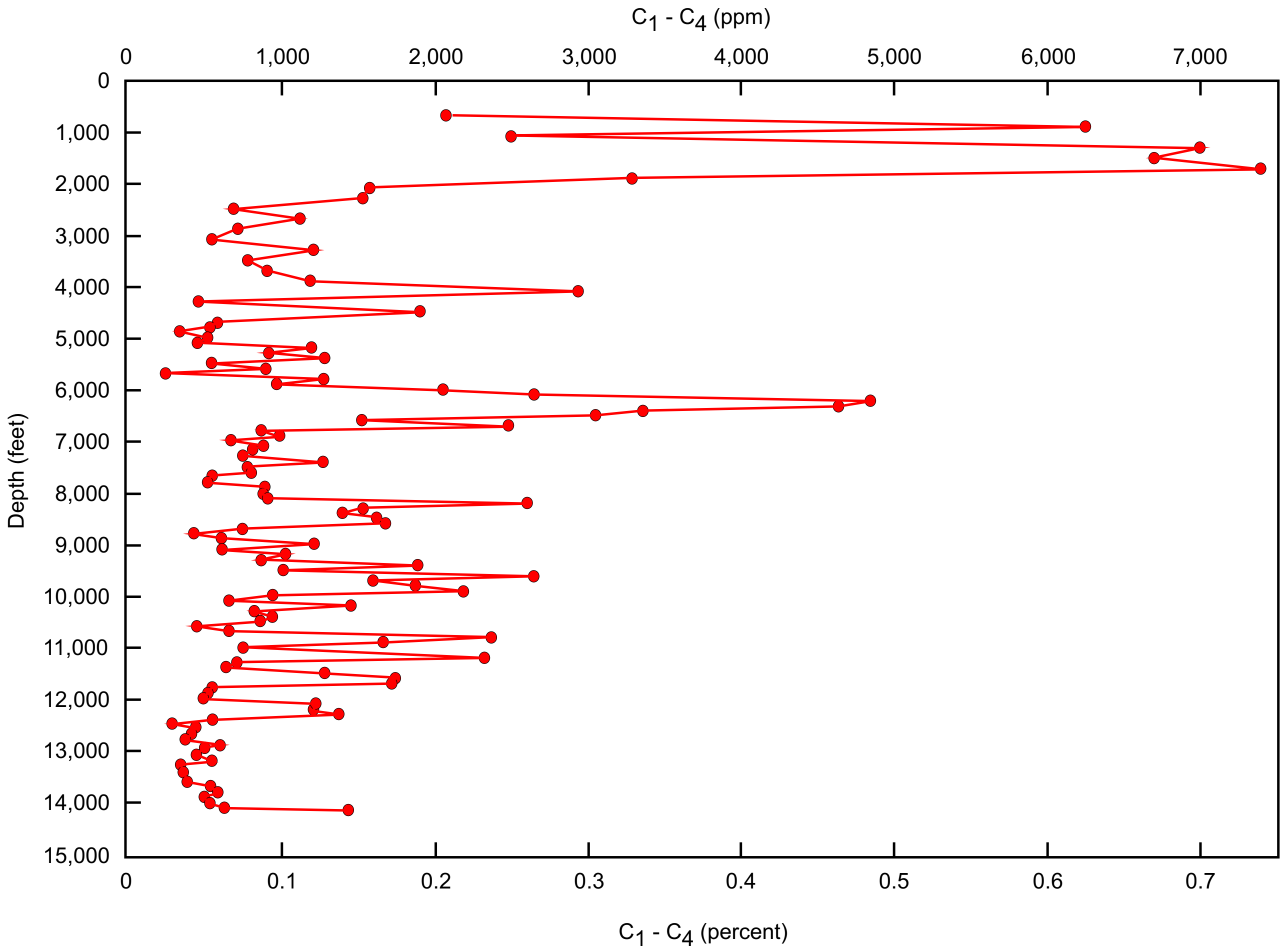

Figure 12. Low-molecular-weight hydrocarbon analysis for the Exxon Lydonia Canyon Block 133 No. 1 well. Data from Exxon.

Table 11. Low-molecular-weight and gasoline-range hydrocarbon analyses

Depth (feet)	C_1-C_4 (ppm)	Gas Wetness (%)	C_4-C_7 (ppm)
670	2,070.43	0.8527	
870	6,251.18	0.3823	
1,070	2,495.53	0.4853	
1,270	6,992.18	0.2845	
1,470	6,698.63	0.2974	
1,670	7,390.85	0.2818	
1,870	3,283.72	0.4611	
2,070	1,579.08	0.5579	
2,270	1,529.84	0.4634	
2,470	695.20	1.1004	
2,670	1,121.45	1.2573	
2,870	719.16	0.6786	
3,070	557.04	1.8311	
3,270	1,213.86	1.3156	
3,470	787.43	1.6725	
3,670	910.21	1.5799	
3,870	1,188.31	0.8264	
4,070	2,929.36	0.6554	
4,270	467.35	2.9378	
4,470	1,901.92	2.0474	
4,670	598.32	2.1794	
4,770	544.74	2.5609	0
4,870	351.36	2.3850	
4,970	523.50	3.8548	
5,070	461.19	3.3088	
5,170	1,202.03	2.0457	
5,270	918.57	4.3644	
5,370	1,283.84	3.9818	
5,470	552.92	4.5902	
5,570	901.19	3.4621	
5,670	255.69	2.4053	
5,770	1,276.27	3.9882	
5,870	973.02	4.3298	
5,970	2,052.23	2.5290	
6,070	2,646.16	4.2363	
6,170	4,845.61	5.7372	
6,270	4,645.07	3.6716	
6,370	3,357.97	7.8407	
6,470	3,052.37	4.8657	

continued

Table 11 Low-molecular-weight--*continued*

Depth (feet)	C_1-C_4 (ppm)	Gas Wetness (%)	C_4-C_7 (ppm)
6,570	1,524.71	8.2134	
6,670	2,472.42	4.4378	
6,770	874.45	6.4338	
6,870	995.21	12.6164	
6,970	684.26	15.1901	0
7,070	889.24	12.4972	
7,170	806.16	8.5306	
7,270	755.80	6.3416	0.976
7,370	1,274.02	4.4285	
7,470	782.79	11.5101	
7,570	811.53	10.2214	0
7,670	553.66	18.8376	
7,770	528.45	17.9411	
7,870	896.40	31.2082	0
7,970	886.72	27.7359	
8,070	920.66	15.1478	
8,170	2,601.72	6.9535	0
8,270	1,532.91	7.6580	1.077
8,370	1,403.54	5.6443	0
8,470	1,627.34	4.8742	
8,570	1,683.16	4.5688	
8,670	755.15	4.4044	1.232
8,770	442.14	12.9439	0.712
8,870	617.39	7.4442	
8,970	1,221.43	2.4185	
9,070	620.09	15.9993	2.397
9,170	1,034.40	4.3648	
9,270	872.92	3.4196	0.969
9,370	1,885.31	1.7371	
9,470	1,019.79	4.1979	0
9,570	2,641.56	1.9227	1.313
9,670	1,601.19	2.7086	0
9,770	1,875.15	1.5711	
9,870	2,183.09	2.2299	0
9,970	949.73	2.5776	
10,070	669.25	2.2144	0
10,170	1,451.46	1.6425	
10,270	833.60	4.2682	
10,370	942.44	3.5567	0
10,470	870.72	2.9401	
10,570	62.93	3.2791	0

continued

Table 11 Low-molecular-weight--*continued*

Depth (feet)	C_1-C_4 (ppm)	Gas Wetness (%)	C_4-C_7 (ppm)
10,670	670.86	2.3343	
10,770	2,365.54	73.1867	0
10,870	1,666.65	5.8405	
10,970	765.61	7.2452	0
11,170	2,324.68	7.6140	0.473
11,270	719.86	14.6233	
11,370	650.72	25.2459	2.107
11,470	1,288.64	18.5646	1.229
11,570	1,743.35	8.3145	0.818
11,670	1,724.93	7.1586	
11,770	560.31	14.4099	0.867
11,870	538.23	17.9143	
11,970	503.87	8.2740	0
12,070	1,230.03	6.4096	
12,170	1,221.27	2.9166	0
12,270	1,379.46	3.6781	
12,370	563.38	6.8089	
12,470	303.45	5.6286	0
12,570	446.40	4.1465	
12,670	423.70	4.1444	0
12,770	391.51	7.9053	
12,870	615.13	3.8106	0
12,970	510.75	6.0891	
13,070	460.99	4.7572	1.982
13,170	562.26	4.4392	
13,270	360.64	12.2116	2.043
13,370	369.97	3.9273	0
13,570	405.08	3.2784	0
13,670	551.90	4.8070	0.882
13,770	600.75	3.8868	0
13,870	513.98	4.2881	0
13,970	551.27	4.3772	0
14,070	648.38	5.9070	4.482
14,118	1,447.69	2.4308	0

section becomes marginally mature. Gas wetness (figure 12) does not increase at a particular depth and then remain elevated below that depth as an indication of thermally mature section. Rather, gas wetness values are variable throughout the well.

Among available data, depth to thermally mature sedimentary section is best indicated by the TAI analysis. With a marginally mature value of 2.7 at 12,630 feet, the bottom of the well appears to be in the upper part of the hydrocarbon evolution window. Peak generation would be deeper than the well.

Assuming 10 million years since onset of petroleum maturation, the time-temperature relationships proposed by Connan (1974) suggest that the temperature for the onset of petroleum generation is about 75 ^{O}C, and peak generation in the oil and gas zone is about 130 ^{O}C. With a geothermal gradient of 1.18 ^{O}F/100 ft (figure 8), the temperature for onset of generation is at a well depth of about 9,000 feet, and the depth of peak generation, about 17,000 to 18,000 feet. Among the assumptions of this approach is that the present-day geothermal gradient represents maximum subsurface temperatures through the Mesozoic and Cenozoic Eras. This is a poor assumption, especially in light of the intrusive igneous unit at 13,200 feet. However, if temperatures had been higher, the generation onset threshold would be shallower than 9,000 feet. The best available time/temperature data, from the TAI analysis, indicate immaturity above 12,630 feet. This apparent conflict may suggest that onset of petroleum generation (given adequate source matter) was more recent than 10 million years.

BURIAL HISTORY

The burial history diagram for the stratigraphic section penetrated by the Exxon LC Block 133 No. 1 well (figure 13) is based on MMS biostratigraphy and on the Cretaceous and Jurassic time scales of Van Hinte (1976a and 1976 b). In general, burial diagrams for Georges Bank wells show rapid Middle Jurassic subsidence followed by moderate subsidence in the Late Jurassic and Cretaceous and low burial rates through the Cenozoic. In those wells for which Neogene biostratigraphic data exist, indicated subsidence increases for this shallowest and most recent part of the section. The Exxon LC Block 133 No. 1 well data show rapid Jurassic and Cretaceous burial rates until the Maestrichtian age, and low rates for the rest of the Late Cretaceous and through the Tertiary until the Miocene age. The increased post-Miocene indicated burial rate is at least partly due to including water depth in the diagram.

In constructing figure 13, no adjustments have been made for sedimentary compaction or for section removed by erosion.

If only the deeper part of the identified Bathonian section is marginally mature for petroleum generation, it has become mature recently in geologic time, perhaps in less than the last ten million years.

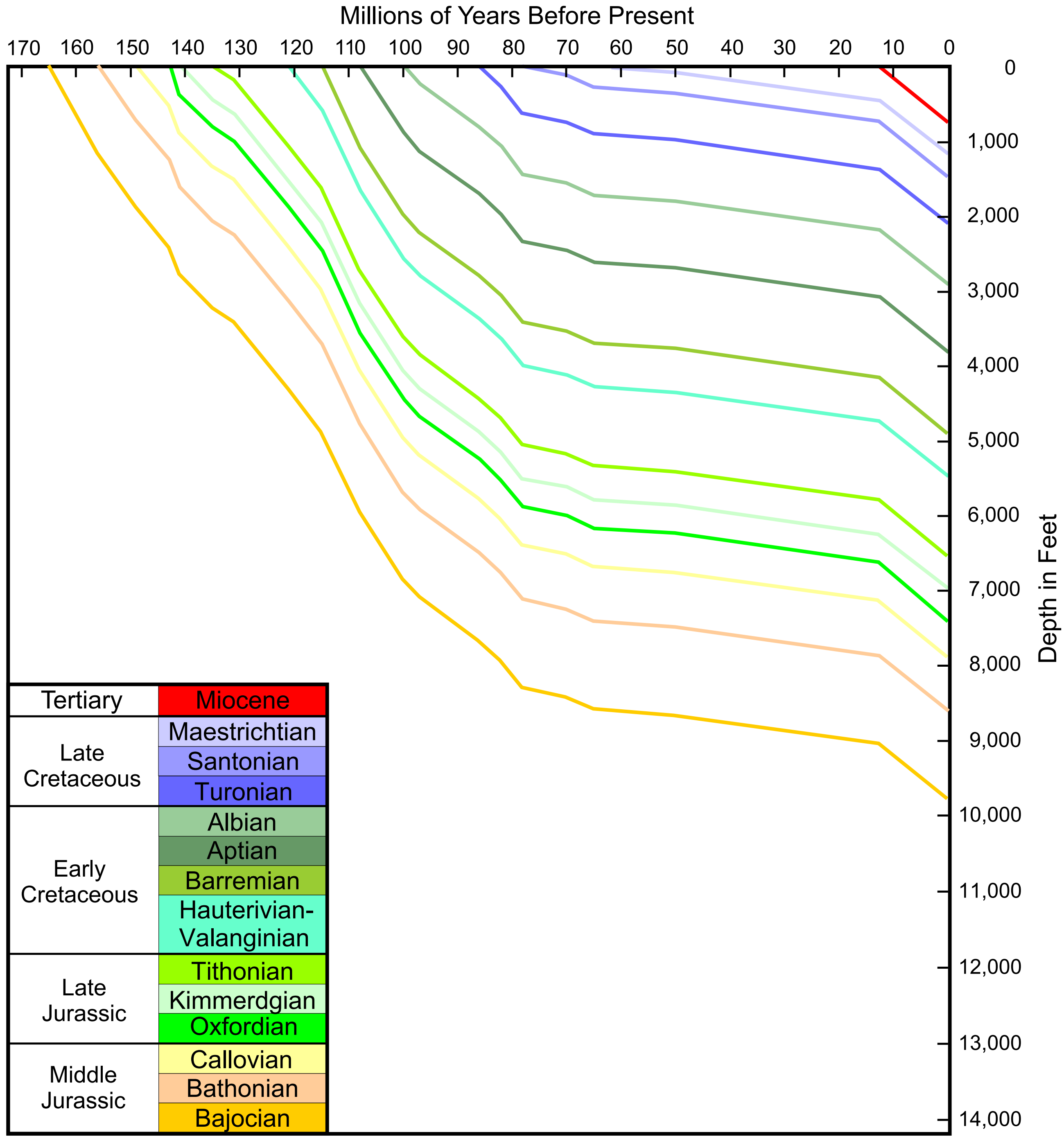

Figure 13. Burial diagram for the Exxon Lydonia Canyon Block 133 No.1 well.

COMPANY-SUBMITTED DATA

Data and reports were submitted by Exxon Corporation, U.S.A., to MMS when the Exxon LC Block 133 No. 1 well was drilled, as required by Federal regulations and lease stipulations. Items of general geological, geophysical and engineering usefulness are listed below. Items not listed include routine submittals required by regulation, such as the Exploration Plan, Application for Permit to Drill, and daily drilling reports, and detailed operations information, such as drilling pressure and temperature data logs. Well "electric" logs are listed in the **Formation Evaluation** chapter. Listed and unlisted company reports and data are available through the Public Information Unit, Minerals Management Service, Gulf of Mexico OCS Region, 1201 Elmwood Park Boulevard, New Orleans, Louisiana 70123-2394; telephone (504)736-2519 or 1-800-200-GULF, FAX (504)736-2620. Well logs are available on microfilm from the National Geophysical Data Center, 325 Broadway Street, Boulder CO 80303-3337, attn. Ms Robin Warnken; telephone (303)497-6338, FAX (303)497-6513; e-mail rwarnken@NGDC.NOAA.GOV.

At a later date, additional original technical data, including well logs, will be added to the compact disk (CD) version of the Georges Bank well reports. The CD will be available from the Gulf of Mexico OCS Region Public Information Unit.

SELECTED COMPANY-SUBMITTED DATA

Physical formation (mud) log, Exploration Logging of USA, Inc., undated.

Seismic velocity survey (checkshot survey), Birdwell Division, Seismograph Service Corp., Tulsa OK, undated.

Velocity survey computation (well velocity and well seismic tool data), Schlumberger Ltd., Wireline Testing, Houston TX, undated.

Core analysis report (sidewall cores), Erco Petroleum Services, Inc., Houston, September 14, 1981.

Conventional core description form (12,251-12,270 and 13,488 -13,491 feet), Exxon Co., U.S.A., Houston, September 18, 1981.

Geochemical analyses (C_1-C_4 and C_4-C_7 hydrocarbon, total organic carbon, and thermal pyrolysis analyses), Exxon Co., U.S.A., Houston, undated.

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