OCS Report
MMS 86-0129

Texaco Hudson Canyon 598-3 Well

Geological & Operational Summary

Edited By
Bruce J. Kobelski

U.S. Department of the Interior
Minerals Management Service
Atlantic OCS Region

1987

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ABSTRACT

Block 598 in the Mid-Atlantic protraction diagram NJ 18-3 (Hudson Canyon) was leased to Texaco, Inc. and partners in Lease Sale No. 40 held on August 17, 1976. Their high bid for this block was $16,830,000. The lease was relinquished on May 21, 1984, at the expiration of the primary term plus a 2-year extension of lease terms.

The Texaco No. 3 Block 598 well was spudded on December 4, 1979, and was plugged and abandoned on May 25, 1980. The well was drilled from the semisubmersible Ocean Victory in 425 feet of water to a total depth of 16,103 feet.

The objective of this well was to test Cretaceous through Jurassic sandstones that were hydrocarbon-bearing in other wells drilled on the same geologic structure. Biostratigraphic analyses identified sediments of Paleocene to Late Jurassic age. The Tertiary sediments are predominantly marls, mudstones, sands, and siltstones, which indicate a middle shelf environment of deposition modified by prodelta facies. Upper Cretaceous sediments are comprised of alternating sequences of calcareous shales, siltstones, and sands with interbedded limestones. An inner to middle shelf environment of deposition is indicated. Lower Cretaceous sediments consist of alternating calcareous sandstones and calcareous siltstones with the lowermost Cretaceous and Upper Jurassic section dominated by carbonate rocks. These sediments indicate a complex marine/nonmarine environment of deposition indicative of an inner shelf/deltaic setting. Lignite and low rank coal within these lower intervals indicate lagoonal, restricted marine subenvironments existed within the deltaic sequences. The Upper Jurassic sediments are comprised of alternating calcareous sandstones, shales, and siltstones. Both lithologic and paleontologic data support an inner shelf to nonmarine environment of deposition.

Although potential reservoirs were encountered throughout the well, drill stem tests failed to produce any flows of hydrocarbons. The conventional core and sidewall core analyses indicate that the Texaco 598-3 well had low porosity and permeability values compared with those of other wells drilled on the same geologic structure.

ABBREVIATIONS

API	-	American Petroleum Institute
bbls	-	barrels
bg	-	background
BSW	-	barrels of salt water
BWPD	-	barrels of water per day
CNL	-	compensated neutron log
delta t	-	difference in two-way travel time
DISFL	-	dual induction-spherically focused log
DST	-	drill stem test
FDC	-	compensated formation density log
FEL	-	from east line
FNL	-	from north line
G_b	-	gas % bulk
HDT	-	high resolution dipmeter
k	-	permeability
KB	-	kelly bushing
ls	-	limestone
md	-	millidarcy
O_b	-	oil % bulk
OCS	-	Outer Continental Shelf
O_p	-	oil % pore
PBTD	-	plugged back total depth
ppg	-	pounds per gallon
ppm	-	parts per million
psi	-	pounds per square inch
RILD	-	resistivity induction log, deep
RILM	-	resistivity induction log, moderate
sh	-	shale
SP	-	spontaneous potential
ss	-	sandstone
Sw	-	water saturation
SWC	-	sidewall core
TD	-	total depth
UTM	-	Universal Transverse Mercator
WD	-	water depth
Ø	-	porosity

OPERATIONAL SUMMARY

by

Khaleeq U. Siddiqui

Statistical Summary

The Texaco Hudson Canyon 598-3 well (figure 1) was drilled by the Ocean Victory semisubmersible drilling rig. The vessel, owned by Ocean Drilling and Exploration Company (ODECO), was built in 1972 by Avondale Shipyards, Inc., of New Orleans, Louisiana, and classified by the American Bureau of Shipping's (ABS) "Rules for Building and Classing Offshore Mobile Drilling Units, 1968" for unrestricted service.

The Ocean Victory is 320 feet long by 266 feet wide, and the main deck is 128 feet above the bottom of the lower hull. The vessel is capable of drilling in water depths of up to 600 feet. The Ocean Victory was inspected before drilling began, and operations were observed by the Minerals Management Service personnel throughout the drilling period to ensure compliance with U.S. Department of the Interior regulations and orders. Davisville, Rhode Island, and Atlantic City, New Jersey, were used as operational bases. Two tug-supply vessels in the 200-foot class were used to transport materials and supplies.

Texaco, Inc., was the operator, and Shell Oil Company, Allied Chemical Corporation, Transco Exploration Company, and Freeport Minerals Company were participating partners. The lease was acquired at OCS Lease Sale 40, August 17, 1976. It was relinquished on May 21, 1984, at the expiration of the primary term plus a 2-year extension of lease terms for additional developmental efforts. Well and drilling information statistics are summarized in table 1. The well's location is shown in figure 2.

Drilling Program

The Texaco 598-3 well was drilled to a total depth of 16,103 feet. Drilling rates of penetration ranged from 4 to 105 feet per hour. The maximum borehole deviation from the vertical was less than 1 degree. Figure 3 shows a curve of the daily drilling progress.

Four strings of casing and a liner were set in the well and are shown in figure 4. The 30-inch casing was set at 790 feet with 1,100 sacks of cement; the 20-inch casing was set at 1,255 feet with 950 sacks of cement; the 13 3/8-inch casing was set at 4,503 feet with 1,900 sacks of cement; the 9 5/8-inch casing was set at 12,502 feet with 3,250 sacks of cement; and the 7-inch liner was set at 15,989 feet with 3,000 sacks of cement with the liner top set at 7,760 feet. Class H cement was used in all casings and liners.

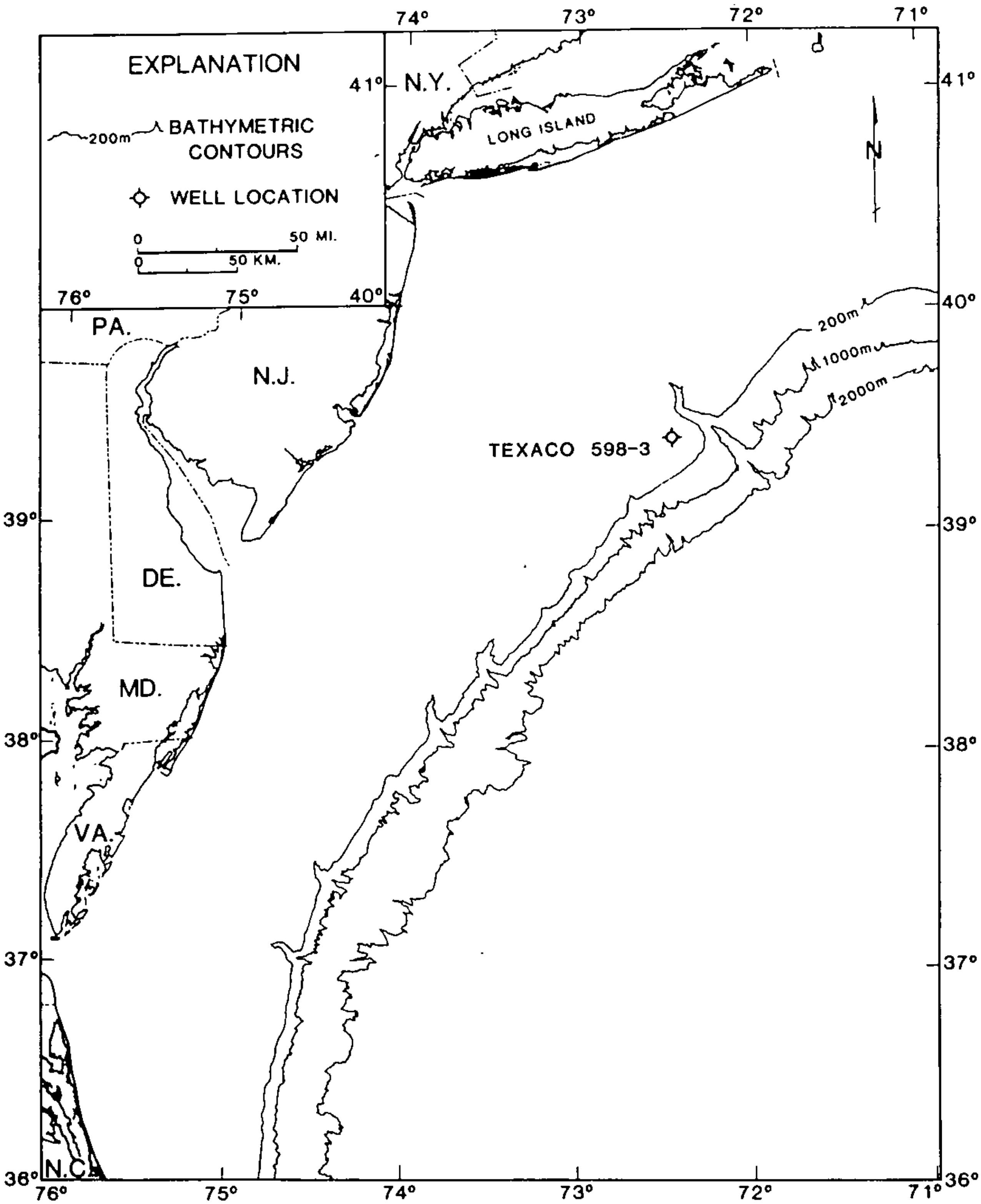

Figure 1.--Map of a portion of the Mid-Atlantic offshore area showing the location of the Texaco 598-3 well.

Table 1.--Texaco 598-3 well statistics

Well identification	API No.: 61-105-00017
Lease number	OCS-A-0028
Protraction diagram	NJ 18-3 (Hudson Canyon)
Surface location	Block 598: 2,138.48 feet FEL 4,173.35 feet FNL Latitude: 39°22'54.733" N. Longitude: 72°29'59.238" W. UTM Coordinates: X = 715,348.19m Y = 4,361,927.96m
Bottom hole location	Vertical hole, same as surface
Proposed total depth	17,000 feet
Actual total depth	16,103 feet
Total measured depth	16,103 feet
Kelly bushing elevation	78 feet above mean sea level
Water depth	425 feet
Spud date	December 4, 1979
Completion date	May 25, 1980
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.

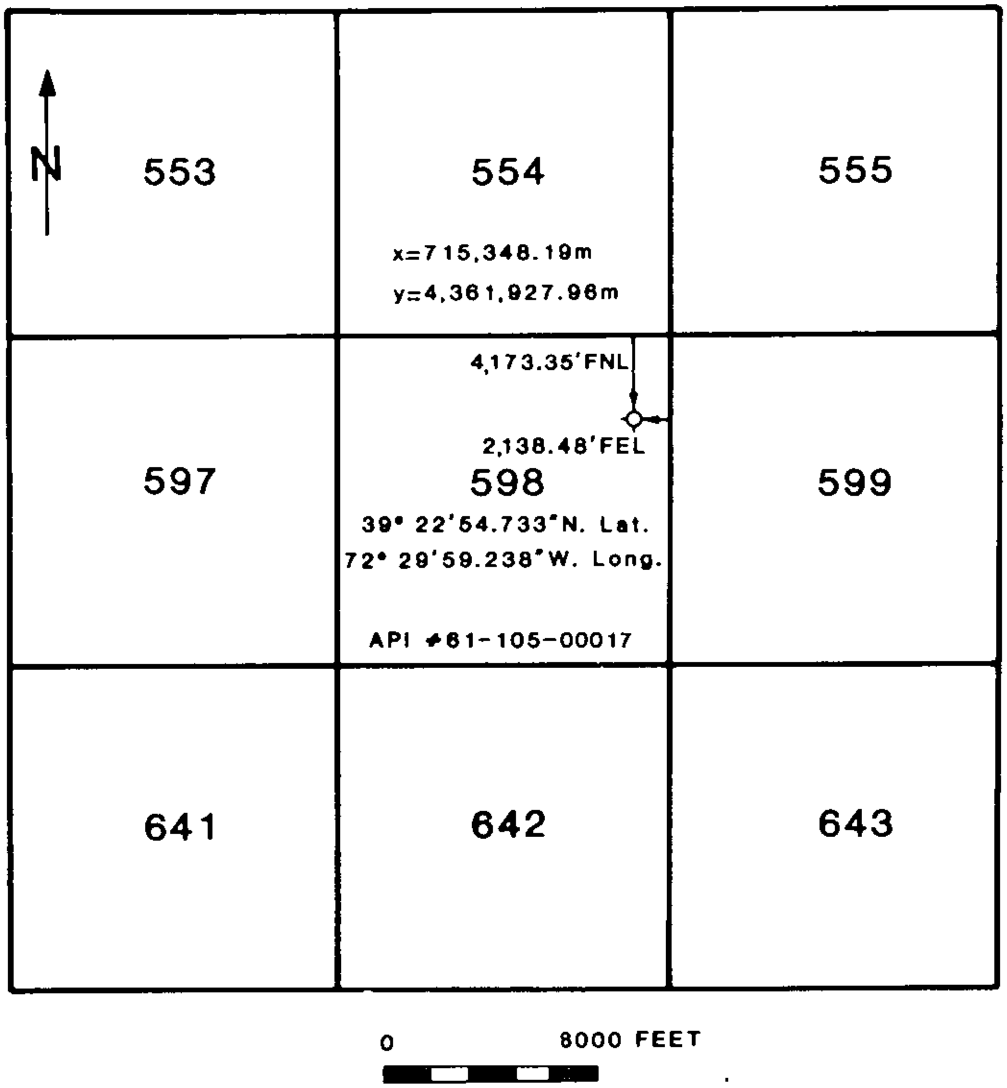

Figure 2.--Plat showing the location of the Texaco 598-3 well in OCS Protraction Diagram NJ 18-3, Hudson Canyon.

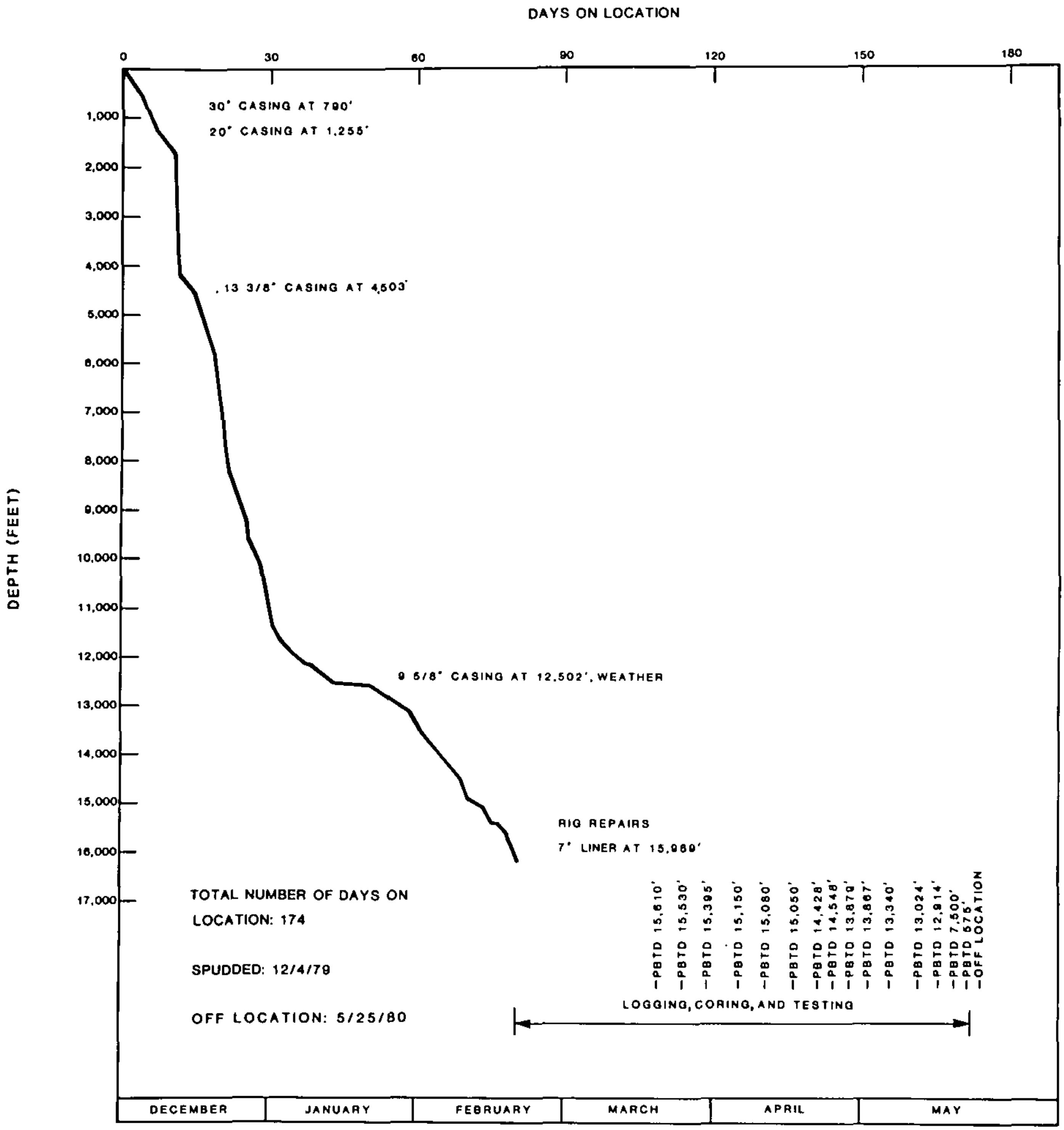

Figure 3.--Daily drilling progress for the Texaco 598-3 well.

DEPTH BELOW KB (FEET)

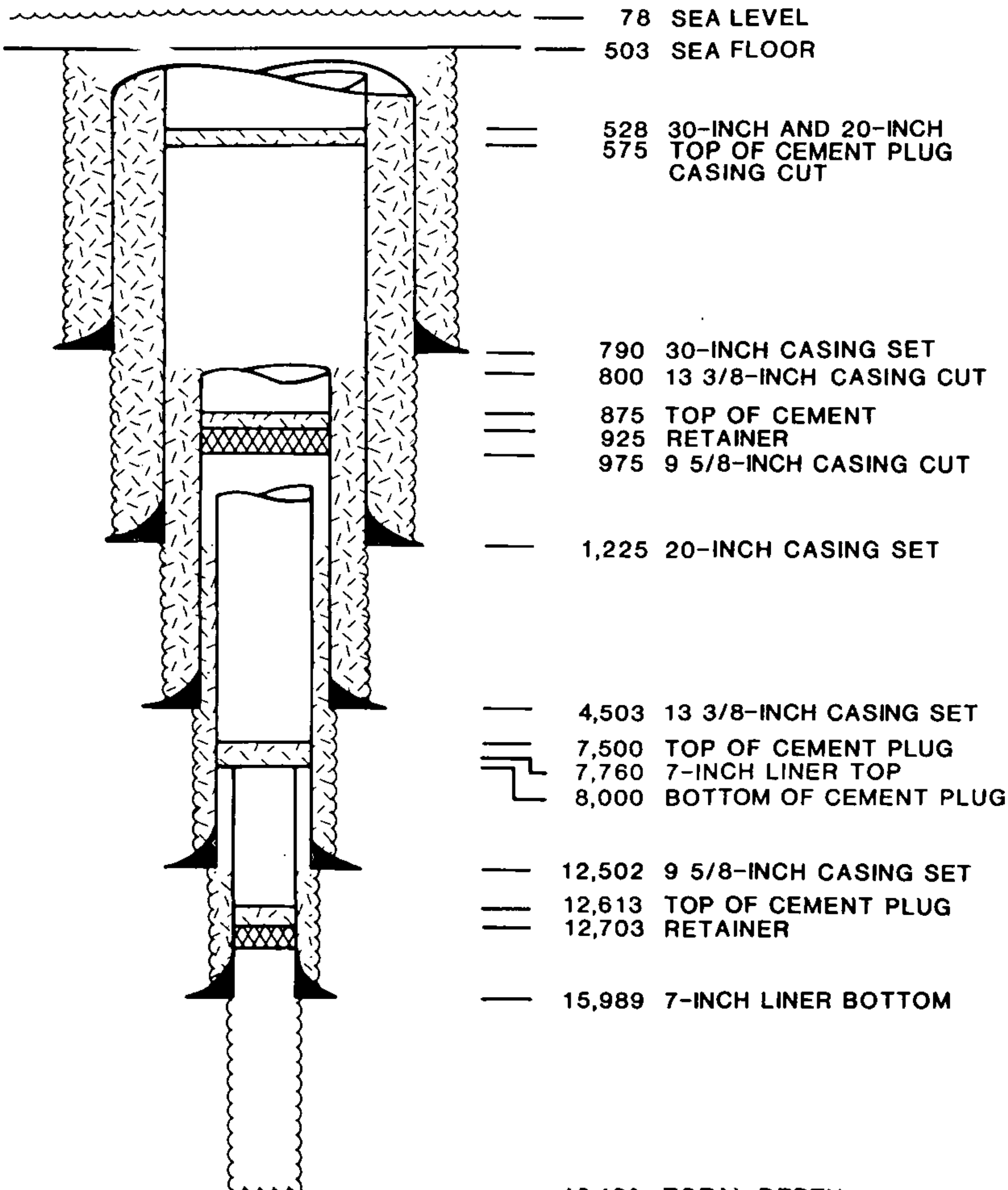

Figure 4.-- Schematic diagram showing the casing and abandonment program for the Texaco 598-3 well.

At a depth of 15,610 feet, drilling was temporarily halted because of leaks in drill collars and the ball valve. The repairs were made to these leaks from March 15 through March 17, 1980.

The abandonment procedure is shown in figure 4. A 7-inch retainer was set at 12,703 feet with 229 sacks of Class H cement squeezed below the retainer and 16 sacks of cement spotted on top. A 142-sack plug was spotted at 8,000 to 7,500 feet. This plug was tested at a pressure of 4,500 psi (pounds per square inch). The 9 5/8-inch casing was cut and recovered at 975 feet, and a retainer was set at 925 feet with 39 sacks of cement spotted on top of the retainer. This cement plug was also tested at a pressure of 4,500 psi. The 13 3/8-inch casing was cut and recovered at 800 feet. A 482-sack cement plug was spotted between 875 and 575 feet.

Mud Program

Seawater and gelled freshwater with a weight of 8.5 ppg (pounds per gallon) were used as a drilling fluid to a depth of 831 feet. The mud weight was increased to 9.3 ppg at 1,303 feet, 9.8 ppg at 9,867 feet, 10 ppg at 12,343 feet, 11.5 ppg at 14,960 feet, reached 12.1 ppg at 16,050 feet and remained at that weight to the total depth of the well. The viscosity of the mud fluctuated between 38 and 43 seconds in the first 13,257 feet and averaged about 52 seconds for the remainder of the well. The mud pH averaged 9.0 with only minor fluctuations. Total chloride concentrations began at 7,000 ppm (parts per million), increased to 26,000 ppm at 11,859 feet, and dropped to 17,500 ppm at total depth.

Samples and Tests

Five conventional cores (table 2) were obtained and analyzed for lithology, porosity, permeability, paleontology, grain density, and hydrocarbon saturation.

Table 2.--Texaco 598-3 conventional core recovery

Core No.	Interval (feet)	Recovery (feet)
1	12,573-12,616	43
2	12,773-12,791	18
3	13,513-13,543	30
4	14,976-15,006	26.5
5	15,352-15,376	24

A series of sidewall cores were taken between 11,482 feet and 16,014 feet; 60 cores were recovered and 38 of these were analyzed for lithology, porosity permeability, and hydrocarbon saturation. There were 11 drill stem tests made in this well, and the results of these tests are given in table 3.

Table 3.--Texaco 598-3 drill stem test results

Test Number	Interval Tested (ft)	Length of Test (hrs)	Choke Size (in)	Final Flow Pressure (psi)	Final Shut-In Pressure (psi)	Results or Recovery
1	15,820-15,875	5	3/8	5,284	6,236	No blow, no flow, tight formation, water cushion only
2	15,563-15,600	7.7	3/8	4,971	7,888	Small blow, no flow, no formation fluid, water cushion only
3	15,445-15,511	10.7	3/8	2,440	7,202	Small blow & flare, no formation fluid
4	15,110-15,142	6.8	3/8	3,321	6,905	Small blow & flare, no formation fluid
5	14,950-14,976	10.5	3/8	4,278	6,469	Failed to flow
6	14,476-14,534	7.4	3/8	5,756	6,261	Failed to flow, recovered 13 bbls of water and 79 bbls of salt water
7	13,816-13,861	6	3/8	1,615	6,129	Failed to flow, reversed out 30.5 bbls of salt water
8	13,270-13,330	5	3/8	5,882	5,899	Failed to flow, recovered 11 bbls of water and 65 bbls of formation fluid
9	13,097-13,110	6.4	3/8	2,157	5,466	Failed to flow, recovered 12 bbls of water cushion, 15 bbls of mud
10	12,974-13,013	10	3/8	5,584	5,748	Flowed formation fluid (salt water) at a rate of 324 bbls/day, total recovery of 105 bbls
11	12,750-12,777	5	3/8	5,621	5,642	Weak blow, no flow, reversed out 13 bbls water cushion and 76 bbls of formation fluid

WELL VELOCITY PROFILE
by
Fred. W. Lishman

An interval velocity profile for the Texaco 598-3 well, which was plotted using data from the Schlumberger Sonic Log, is shown in figure 5. Four depth intervals are identified on the basis of changes in the relative interval velocities between 4,422 feet, the shallowest data, and 16,009 feet, the deepest data. The velocities of all four intervals are consistent with predominantly clastic lithologies; however, the moderately higher velocities of intervals II and III suggest an increased percentage of carbonates. These four depth intervals and their inferred lithologies generally agree with the facies units identified in the lithologic log.

<u>Interval I</u>: This section is identified on the basis of relatively low velocities. Predominantly clastic lithologies are indicated by these velocities.

DEPTH RANGE (feet)	4,422-7,672
INTERVAL VELOCITY RANGE (feet/second)	6,650-10,100
AVERAGE INTERVAL VELOCITY (feet/second)	9,155

<u>Interval II</u>: This section is defined by higher velocities than those found in interval I. These velocities suggest continental clastic lithologies with sandstone predominating. An anomalous velocity of 12,500 feet per second occurs between 7,925 feet and 8,175 feet and may represent an increase in carbonate material.

DEPTH RANGE (feet)	7,672-10,472
INTERVAL VELOCITY RANGE (feet/second)	11,175-12,500
AVERAGE INTERVAL VELOCITY (feet/second)	11,814

<u>Interval III</u>: This section is identified on the basis of gradually increasing velocities. These velocities suggest primarily clastic lithologies with the percentage of carbonate material increasing with depth.

DEPTH RANGE (feet)	10,472-12,122
INTERVAL VELOCITY RANGE (feet/second)	12,580-14,380
AVERAGE INTERVAL VELOCITY (feet/second)	13,306

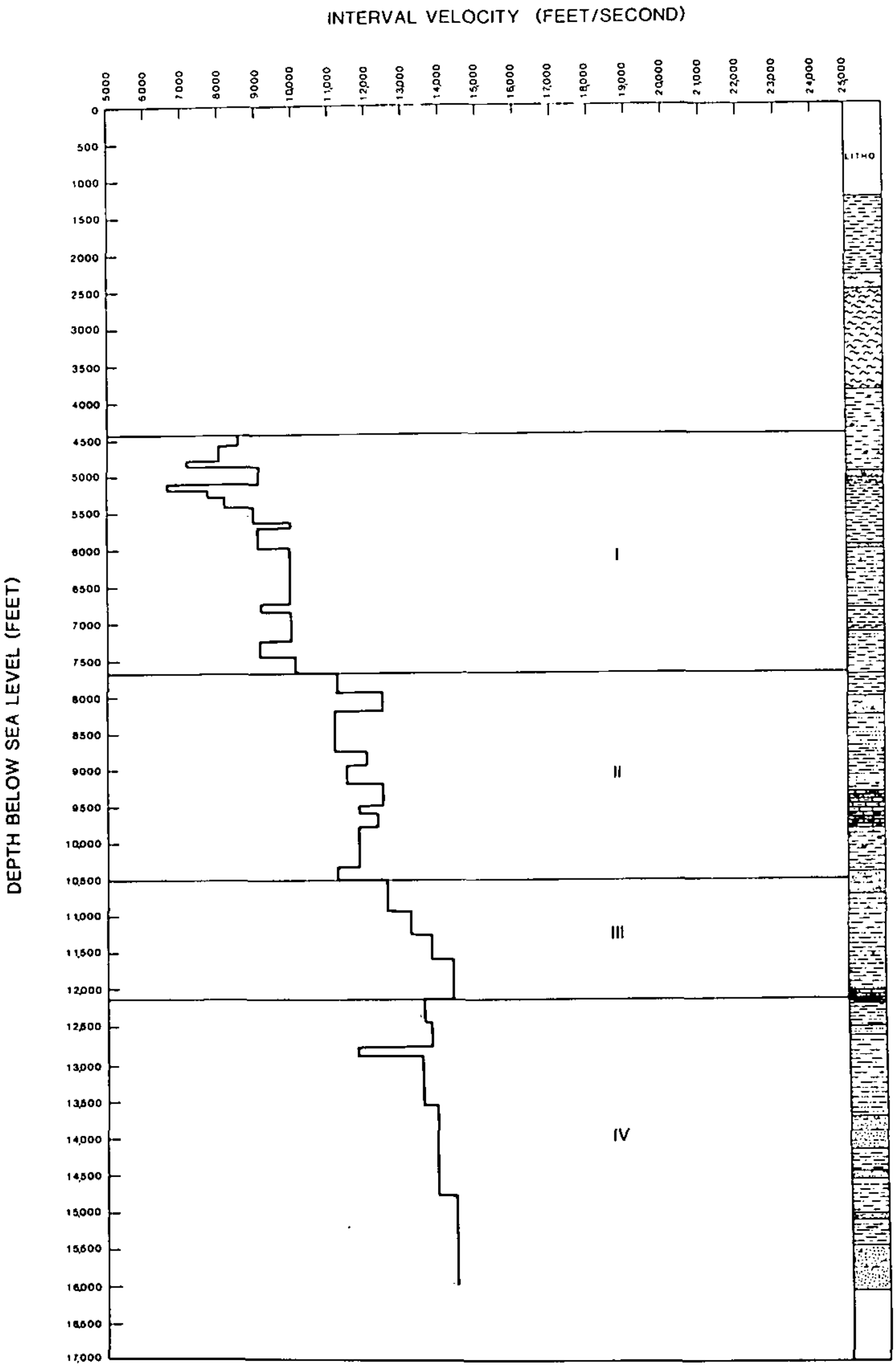

Figure 5.--Interval velocity profile for the Texaco 598-3 well.

Interval IV: This section is defined by relatively low velocities. Predominantly clastic lithologies are indicated by the velocities in the final interval of the well. An anomalous velocity of 11,750 feet per second occurs between 12,750 feet and 12,875 feet and corresponds with a coal-bearing zone identified in the lithologic log.

DEPTH RANGE (feet)	12,122-16,009
INTERVAL VELOCITY RANGE (feet/second)	11,750-14,390
AVERAGE INTERVAL VELOCITY (feet/second)	13,833

LITHOLOGIC INTERPRETATION
by
George Carpenter

Geologic data used as the basis for this report consisted of sidewall and conventional cores, drill cuttings, and thin sections. Cuttings were continuously collected from 1,300 to 16,100 feet. The sample quality was generally good except that much of the clay/silt fraction was not recovered from poorly indurated sediments in the upper few thousand feet of the section. The sample collection interval was 30 feet, which required the use of electric logs to locate distinct lithologic boundaries. Paleobathymetric interpretations are based on the occurrence of various lithologic indicators (i.e. coal, oolites, red beds) and on the distribution of depth-sensitive microfossils.

Important rock stratigraphic units are given by depth intervals. No generally agreed nomenclature for formations or formation equivalents exist for the Baltimore Canyon Trough; therefore, the stratigraphic units in this report are unnamed. However, the units described in this report have geologic continuity over large vertical and horizontal distances and correlate well in gross character with nearby wells. The lithologic units shown in figure 6 are described beginning with the uppermost (youngest) section.

Lithologic Descriptions

1,300 to 4,930 feet

This interval is a sequence of poorly indurated marls, mudstones, and sands. The marls contain substantial fractions of glauconite and thick-walled, marine pelecypod fragments. The sequence becomes progressively better indurated with depth. These unconsolidated sediments also contain biogenic methane; shows of up to 300 gas units were measured on the mud log in this interval. Sand beds within this interval are thick (>50 feet), poorly consolidated (with some calcite cement), and contain minor amounts of glauconite and marine shell fragments. Individual grains are subangular to subrounded, frosted, and range in size from coarse to very fine. The grain size in any given bed is remarkably uniform (well sorted).

4,930 to 8,030 feet

The sediments in this interval consist of alternating sands and calcareous siltstones. The siltstones show considerable variability in their degree of induration, in some cases approaching the consistency of marl. They typically include a suite of second-order components such as micas, pyrites, glauconite, sand, and macrofossil fragments. The sands are well sorted, fine grained, subangular, and slightly calcareous because of calcitic cementation. The upper sand unit is heavily iron stained. The sands in this interval are also slightly to poorly consolidated.

8,030 to 9,050 feet

This interval is similar to the previous interval except that it was probably deposited in shallow water. It is an alternating sequence of fine-grained sandstones and calcareous siltstones. The siltstones contain minor amounts of glauconite and pyrite and, in one bed, traces of soft, low-rank coal. The sands are poorly indurated, slightly calcareous, well sorted, and contain glauconite. The sands also contain fragments of thick-walled pelecypod shells. The individual sand grains are subrounded to subangular, frosted, and fine to very fine in size. Thin section examination reveals that little primary porosity is lost because of calcitic cementation or contamination by clay/silt particulates.

9,050 to 12,200 feet

The sediments in this interval are primarily carbonates. The beds are comprised of limestones, calcareous sands, shales, or siltstones. The sandstones tend to be well consolidated and slightly to moderately calcareous. Siltstones occur as laminae within the sandstones or as a second-order component partially filling the intergranular voids. Cementation in the sands consists of recrystallized calcite. Shales and siltstones range in color from buff to black and are slightly to moderately calcareous. They include minor amounts of sand and coal. Some black shales appear to be carbonaceous and occur as partings and laminae within the siltstone beds. The limestones are gray to buff in color, silty, sandy, and have an earthy/chalky texture. There is little evidence of secondary alteration (dolomitization).

12,200 to 16,100 feet

This interval is a massive sequence of alternating sands and shales. Most of the individual beds are slightly to moderately calcareous and contain minor amounts of coal and glauconite. This interval is within the thermally mature zone for hydrocarbons, and gas shows are common. The individual grains of the sandstones are subrounded to subangular, frosted, well sorted, and range in size from fine to coarse. Thin section examination reveals that sands in this interval have primary porosity reduced by calcitic cementation (in some cases replaced by dolomite) or by contamination with clay and silt particles. The shale and siltstone beds within the interval range in color from brown to gray to black, are slightly calcareous, and also contain minor amounts of sand and coal. Shales and siltstones also occur as partings and laminae within the sand beds. The shales are occasionally carbonaceous and include trace amounts of pyrite.

Reservoir Potential

The Texaco 598-3 well was drilled on a complexly faulted anticline southwest of the Hudson Canyon in the Baltimore Canyon Trough. It was one of eight wells drilled by the oil industry in order to ascertain the presence of economic hydrocarbon reserves, as several of these wells produced substantial rates of natural gas on tests. However, the Texaco 598-3 well did not produce any hydrocarbons during drill stem testing, although shows of up to 1,600 units of gas were recorded on the mud log.

Limestone as a distinct lithology is nearly absent from this well. The potential reservoirs are limited to sandstones. Much of the primary porosity in the sandstones has been lost to calcitic cementation, which increases with depth. The development of secondary porosity by fracturing, dolomitization, or other diagenetic processes is minimal.

Numerous sidewall cores and five conventional cores were recovered to fully evaluate this well. Porosity and permeability calculations from electric logs and core analyses indicate fairly low porosity and low permeability values, but a number of sands could be interpreted as gas productive in the thermally mature zone below 12,200 feet. The locations of the conventional cores are shown in figure 6. Cores 1, 3, 4, and 5 indicate porosities up to 19 percent but permeabilities generally less than 10 md. Only core 2 (12,773-12,791 feet) in a medium-grained sandstone has both good porosity (ϕ >14%) and good permeability (k >10 md). Two 1-foot zones in core 4 have porosities of 18 percent and permeabilities greater than 10 md.

Although porosity and permeability values are low in this well, the preliminary geochemical analysis indicates that the Texaco 598-3 well has a slightly better kerogen content than other wells drilled on this geologically complex structure.

BIOSTRATIGRAPHY

by

Raymond E. Hall, William Steinkraus, and John Bebout

For this report, fossil foraminifera, dinoflagellates, spores, pollen, and calcareous nannofossils were used to determine the biostratigraphy and chronostratigraphy of the Texaco Block 598-3 well. Paleontological and paleoenvironmental studies were made from well cuttings processed by Geochem Laboratories, Inc. Paleontological analysis of the cuttings were performed on 30-foot composite intervals for calcareous nannoplankton and planktonic and benthic foraminifers, while palynomorphs were analyzed from 90-foot composite samples. Calcareous nannofossil studies were made from 255 slides in the 4,870 to 12,820 foot interval. Planktonic and benthic foraminiferal studies were made from 233 samples between the interval of 4,780 to 11,950 feet.

Three factors limit the reliability of paleontologic data. First, most analyses are made from drill cuttings samples, which are often contaminated by cavings from higher in the drill hole. For this reason, only "tops" or the uppermost species appearances are recorded. Second, reworked, older fossil assemblages and individual specimens are commonly incorporated in detrital sedimentary rocks. These fossils must be recognized so that misdating an interval can be avoided. Third, biostratigraphic control is poor in pre-Upper Jurassic strata. Calcareous nannofossils and foraminifers are rare to nonexistent. Palynomorphs are more common, but their biostratigraphic distribution is not fully documented with reference to the European type stage localities. This report relies on the Jurassic palynostratigraphy of offshore eastern Canada (Bujak and Williams, 1977) because many of their palynomorph marker species are also present in the United States Atlantic offshore subsurface. Although the European stage equivalence of several species is not fully resolved, some species have recently been documented in European type sections (Woollam and Riding, 1983; Riding, 1984; and Davies, 1985).

Summary

The total section examined ranges in age from Paleocene to Late Jurassic. A recognizable unconformity exists between the Paleocene and Late Cretaceous. Barremian through Hauterivian stage markers have not been identified from either the calcareous nannofossils or benthic and planktonic foraminiferal groups. The interval from 8,110 to 11,290 feet has not been examined for palynomorphs. The age of this interval is considered indeterminate. Biostratigraphy and paleobathymetry are summarized on figure 6, p. 13.

Cenozoic

Tertiary

Paleocene (<4,780 feet)--The Paleocene is identified by the highest occurrence of the planktonic foraminiferal species *Globorotalia angulata* and *G. velascoenis* at 4,780 feet. The nannofossils *Fasciculithus tympaniformis* and *F. involutus* are present at 4,870 feet, while the nannofossil *Heliolithus kleinpelli* has its highest occurrence at 4,900 feet.

Mesozoic

Cretaceous

Late Cretaceous

Campanian (4,930-5,680 feet)--The highest occurrence of the nannoplankton species *Chiastozygus initialis* and *Broinsonia parca* at 4,930 feet identifies the Campanian stage. The palynomorph *Paleohystrichophora infusoriodes* is first represented at 5,050 feet, while the planktonic foraminifera *Globotruncana ventricosa* has its highest occurrence at 5,380 feet. The nannofossil *Eiffellithus eximius* is present at 5,470 feet. Foraminifera are sparse throughout the interval with the most prominent benthics being the genera *Bulimina*, *Brizilina*, *Cibicides*, *Dentalina*, *Reussella*, and *Haplophragmoides*.

Santonian (5,680-6,040 feet)--The Santonian is identified by the highest occurrence of the palynomorph *Chatangiella victoriensis* and the nannofossil *Marthasterites furcatus* at 5,680 feet. The environment of deposition is considered to be inner neritic on the basis of the presence of the benthic foraminifera *Gavelinopsis* with occasional *Marginulina* and *Lagena* present between 5,680 to 5,800 feet. The inner neritic environment between 5,800 to 6,040 feet again contains the benthic foraminifera *Gavelinopsis* in association with the following genera: *Tritaxia*, *Dorothia*, *Nodosaria*, and *Globorotalites*. Foraminifera are extremely rare throughout this interval.

Coniacian (6,040-6,820 feet)--The Coniacian is identified by the highest occurrence of the palynomorph cf. *Costatoperforatosporites foveolatus* at 6,040 feet. Foraminifera are rare to absent throughout this interval making it difficult to identify an environment of deposition.

Turonian (6,820-7,000 feet)--The highest Turonian marker is the nannofossil *Radiolithus planus* at 6,820 feet and the planktonic foraminifera *Praeglobotruncana stephani* at 6,850 feet. Benthic foraminifera present within the interval are *Spirillina*, *Nodosaria*, and *Lenticulina*. Echinoid spines have also been found in several samples.

Cenomanian (7,000-8,110 feet)--The Cenomanian is first represented at a depth of 7,000 feet by the benthic foraminifera Gavelinopsis cenomanica. Rotalipora ?deecki and R. cushmani have their highest occurrence at 7,120 feet and 7,150 feet, respectively. The nannofossil Corollithion kennedyi has its highest occurrence at 7,750 feet. The benthic foraminiferal fauna contains the genera Nodosaria, Neoflabellina, Gavelinopsis, and Lagena.

Early Cretaceous

Albian-Aptian (?) (8,110 feet)--The palynomorph Eucommiidities minor/troedssonii has its highest occurrence at 8,110 feet. This species is considered by Bebout (1981) as representing the Albian stage. The benthic foraminifera Lenticulina nodosa also has its highest occurrence at this same depth and represents the Aptian stage.

Valanginian (11,290-11,350 feet)--The highest occurrence of the benthic foraminifera Everticyclamina virguliana identifies the Valanginian at 11,290 feet. Foraminifera are rare to absent throughout this interval.

Berriasian (11,350-11,440 (?) feet)--The Berriasian is first represented by the nannofossil Polycostella senaria at 11,350 feet.

Jurassic

Late Jurassic

Tithonian (>11,440 (?) feet)--The Tithonian is tentatively identified by the highest occurrence of the benthic foraminifera Epistomina cf. uhligi at 11,440 feet. This form may not be a true E. uhligi and therefore may not be a reliable Tithonian marker.

The nannofossil species Hexalithus noelae and Polycostella beckmannii have their highest occurrence at 11,890 feet. The species noelae does not range above the Tithonian and establishes a true Jurassic top at this depth. Epistomina uhligi has its highest occurrence at 11,920 feet.

DEPOSITIONAL SETTING
by
Donald W. Olson

This depositional environment interpretation is based on the lithologic analysis of cuttings and thin sections presented earlier in this report, the interpretation of electric well log responses, and correlations with nearby wells. The geologic age data and paleobathymetry used for this section were derived from the biostratigraphy section of this report. The depths of lithologic boundaries were adjusted to depths recorded on the electric and mud logs. All depths indicated are measured from the kelly bushing. The paleoenvironments are also indicated on figure 6, p. 13.

Depositional Environment

<u>1,300 to 4,930 feet</u>

The Tertiary sediments from 1,300 to 4,930 feet consist of poorly indurated marls, mudstones, and sands. The marls contain substantial amounts of glauconite and marine pelecypod shell fragments. The shell fragments and pelagic foraminiferal tests examined indicate open marine conditions, and increase in abundance with depth. The glauconite indicates a low rate of deposition in a middle shelf environment, pointing to nearby upwelling with lower water temperatures. The sands occur as beds, approximately 50 feet thick, interbedded within the marls and mudstones. These interbedded sands, exhibited in the cuttings, represent regressive pulses of a shelf/prodelta facies. Electric log responses show a good shale baseline; however, logs were not run until a depth of 4,500 feet. Foraminifera slide data start at 4,780 feet and indicate a middle shelf environment to the bottom of the interval.

<u>4,930 to 8,030 feet</u>

The Campanian to Cenomanian (Upper Cretaceous) sediments consist primarily of an alternating sequence of calcareous shales, siltstones, and sands. The overlying Tertiary sediments rest unconformably on a Campanian sand unit approximately 190 feet in thickness. This sand unit is heavily iron stained, suggesting subareal deposition. Immediately below this sand unit is a marine transgressive sequence which can also be observed in the other wells of the Hudson Canyon Block 598 Structure. Electric log responses exhibit a flat SP (spontaneous potential) and little resistivity deflection, except in calcareous streaks and in thin-bedded limestones. Occasionally within coarsening sands there are short deflections to the negative side of the shale baseline, which is an indication of a shelf/prodelta facies. Paleontologic data indicate that the Campanian rocks comprising the upper portion of the shale from 5,120 to 5,680 feet, immediately under the sand unit, were deposited in an inner shelf environment. The paleontologic data also show that the remainder of this interval, down to 8,030 feet, was deposited in a middle shelf environment.

8,030 to 9,050 feet

Albian-Aptian rocks (Lower Cretaceous) from 8,030 to 9,050 feet consist of alternating sandstones and calcareous siltstones. The sands contain fragments of thick-walled, marine, pelecypod shells indicating deposition in shallow water. These sediments exhibit a complex stratigraphic section of interfingered marine and nonmarine strata characteristic of a shelf/-deltaic setting. The presence of lignite and soft, low-rank coal within the sands and siltstones indicate that lagoonal, restricted marine sub-environments existed within the deltaic sequence. The paleontologic data are consistent with this, indicating an inner shelf bordering on nonmarine environment for this interval. Diagnostic electric log responses mostly reflect changes in grain size. Spontaneous potential responses exhibit very blocky, rectangular, and serrated shapes depending on the location within the deltaic facies.

9,050 to 12,200 feet

The sediments in this interval are primarily carbonates, either limestones, calcareous sands, calcareous shales, or calcareous siltstones of the Albian-Aptian to Tithonian (Lower Cretaceous to Upper Jurassic) stages. Some of the limestones are partly dolomitized, possibly from leaching by freshwater. The sediments of this interval appear to have been deposited in an inner shelf environment. The presence of trace amounts of coal in the cuttings may indicate episodes of shoaling. Paleontologic data show the upper portion of this interval, from 9,050 down to 10,690 feet, was deposited in an inner shelf bordering on nonmarine environment. The paleontologic data indicate that from 10,690 to 12,200 feet the depositional setting was inner shelf. Over the entire interval the SP log responses again exhibit the various shapes that are characteristic of an inner shelf/deltaic environment of deposition.

12,200 feet to 16,103 feet (TD)

The interval of Tithonian to Kimmeridgian (Upper Jurassic) sediments is a sequence of alternating sandstones, shales, and siltstones. The sand-stones and siltstones are moderately calcareous and contain minor amounts of coal and glauconite. The shales contain minor amounts of coal and pyrite. On the basis of the lithologic analysis, the environment of deposition of these sediments is nearshore, perhaps deltaic. The paleontologic data support this by showing the paleoenvironment for this interval was inner shelf, bordering on nonmarine. In addition, the SP log responses over this interval again exhibit the shapes that are characteristic of an inner shelf/deltaic depositional setting.

FORMATION EVALUATION
by
Renny R. Nichols

Schlumberger Ltd. ran the following well logs (table 4) in the Texaco 598-3 well to provide information for stratigraphic correlation and for evaluation of formation fluids, porosity, and lithology.

Table 4.--Well logs, Texaco 598-3

Log Type	Depth Interval (ft) below KB
Dual Induction-Spherically Focused Log (DISFL)	4,500-16,087
Borehole Compensated Sonic Log (BHC)	4,500-16,087
Compensated Neutron/Formation Density Log (CNL/FDC)	4,498-16,086
High Resolution Dipmeter (HDT)	4,500-12,522

Exploration Logging, Inc., provided a Formation Evaluation Log ("mud log") which included a rate of penetration curve, a sample description, and a graphic presentation of hydrocarbon shows encountered (830-16,100 ft). In addition, a Drilling Data Pressure Log (830-16,100 ft) and a Pressure Analysis Log (850-16,100 ft) were run.

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 hydrocarbon 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 substantiate the estimates shown in table 5.

Table 5.--Well log interpretation (summary)

Depth Interval (ft)	Feet of Potential Reservoir[1]	Average Porosity (%)	Water Saturation (%)	Feet of Hydrocarbon[2]
4,946-5,076	108	29		
5,936-6,053	94	34		
6,171-6,179	8	34		
6,237-6,246	9	35		
6,261-6,274	13	28		
6,514-6,542	21	29		
7,351-7,362	11	35+		
8,040-8,099	52	24		

Table 5.--Well log interpretation (summary)--Continued

Depth Interval (ft)	Feet of Potential Reservoir[1]	Average Porosity (%)	Water Saturation (%)	Feet of Hydrocarbon[2]
8,122-8,216	63	25		
8,294-8,310	16	30		
8,324-8,360	34	27		
8,376-8,528	139	27		
8,558-8,663	97	27		
8,674-8,729	41	28		
8,751-8,794	43	27		
8,828-8,870	34	21		
9,050-9,126	63	26		
9,142-9,164	22	26		
9,174-9,208	34	27		
9,231-9,280	40	26		
9,468-9,484	16	25		
9,506-9,524	18	21		
9,530-9,548	14	26		
9,657-9,684	20	25		
9,712-9,752	29	26		
9,782-9,800	12	22		
9,859-9,880	21	26		
9,904-9,946	32	28		
9,995-10,116	105	26		
10,150-10,169	19	28		
10,202-10,240	34	25		
10,254-10,274	20	25		
10,313-10,358	45	26		
10,379-10,451	69	26		
10,468-10,501	33	26		
10,534-10,552	18	27		
10,607-10,636	26	20		
10,691-10,705	14	28		
10,759-10,797	21	29		
10,846-10,889	34	26		
10,911-10,927	12	27		
10,935-10,954	13	20		
10,986-11,000	14	29		
11,068-11,084	16	24		
11,117-11,128	11	22		
11,324-11,344	20	16		
11,480-11,495	15	18	47	
11,549-11,562	13	16		
11,720-11,731	11	18		
11,943-11,953	10	11	61	

591
3320

Table 5.--Well log interpretation (summary)--Continued

Depth Interval (ft)	Feet of Potential Reservoir[1]	Average Porosity (%)	Water Saturation (%)	Feet of Hydrocarbon[2]
12,204-12,292	25	11	52	
12,334-12,346	12	16	29	
12,379-12,404	13	5	96	
12,462-12,486	21	22	48	
12,550-12,626	30	8		
12,696-12,707	11	11		
12,744-12,846	48	10	60	
12,973-13,013	40	20	48	
13,096-13,141	33	16	39	
13,202-13,229	25	7	66	
13,271-13,332	52	15	56	
13,492-13,513	16	10		
13,628-13,652	24	13		
13,700-13,732	32	9		
13,816-13,858	26	13		
13,924-13,973	46	12		
14,002-14,058	46	12		
14,104-14,156	47	15		
14,246-14,304	58	12		
14,344-14,384	38	11		
14,434-14,533	90	13		
14,578-14,598	20	12		
14,699-14,754	47	12		
14,856-14,880	24	13		
14,955-14,974	19	13		
15,108-15,172	53	11	46	
15,208-15,222	14	15	23	
15,300-15,337	37	11		
15,402-15,416	14	15	43	
15,433-15,512	77	11	46	
15,562-15,658	89	10	45	
15,678-15,702	20	17	52	
15,750-15,786	34	11	36	
15,822-15,876	51	12	42	
15,898-15,973	59	16	67	
16,008-15,032	24	10	82	
16,059-15,079	20	8	57	

[1]Generally in beds > 10 ft thick and Ø > 5%.
[2]DST results indicate that no "feet of hydrocarbon" were encountered in this well.

The electric logs were of acceptable quality; however, some difficulties were encountered. Run three of the DISFL (12,510-16,087 feet) presents most permeable zones as being effected by an "annulus" (RILM < RILD). This presentation is false and is probably the result of the effects of hole enlargement on the medium induction device. There is also poor repeatability for RILD at 13,640-13,650, 13,940-13,960, and 14,590-14,600 feet. To a depth of 4,552 feet, the CNL reads off scale indicating porosities in excess of 60 percent. Washouts in excess of 18 inches occur at 5,190-5,770, 6,890-7,925, 11,020-11,480 and 12,830-15,250 feet with substantial effect on the porosities indicated by the density and neutron devices. The CNL/FDC became stuck at 13,840, 14,590, and 14,750 feet, causing aberrations in the corresponding readings.

A summary of the sidewall core (SWC) analysis is shown in table 6. A comparison of SWC porosities with log-derived porosities is shown in table 7.

Table 6.--Sidewall core analysis (summary)

Depth Interval (ft)	Lith.	Porosity Range (%)	Permeability Range (md)	Gas % Bulk Range
11,482-12,984	ss	12.7-21.9	0.5-17.0	3.7-11.9
13,067-13,217	ss	16.1-22.6	1.2-28.0	3.8-4.2
13,224-14,364	ss	14.9-20.8	1.1-16.0	5.2-11.1
14,435-15,168	ss	14.1-19.2	0.4-5.7	3.7-5.8
15,209-16,014	ss/ls	12.9-18.8	0.3-3.5	5.7-9.2

Table 7.--Sidewall core comparison with electric log porosity

Depth	SWC	Neutron	Density	Sonic	
(ft)	Porosity	Porosity	Porosity	delta t	Porosity
11,482	22	33	24	73	13
11,490	17	20	20	71	12
11,492	17	21	21	72	12
12,330	19	30	12	73	13
12,338	20	27	16	83	21
12,340	20	21	16	83	21
12,342	21	19	16	80	18
12,460	13	30	16	78	17
12,465	17	29	20	88	24
12,481	18	23	18	81	19
12,770	20	20	15	78	17
12,967	18	21	13	76	15
12,984	21	21	18	80	18
13,067	16	20	20	82	20
13,092	16	24	12	70	11
13,101	17	23	13	70	11
13,103	23	24	15	80	18
13,217	20	26	10	74	14

Table 7.--Sidewall core comparison with electric log porosity--Continued

Depth (ft)	SWC Porosity	Neutron Porosity	Density Porosity	Sonic delta t	Sonic Porosity
13,224	21	24	12	72	12
13,635	19	22	13	74	14
13,728	19	14	10	68	10
14,122	20	18	18	75	15
14,243	17	27	6	72	12
14,257	17	16	14	73	13
14,353	15	20	15	72	12
14,364	19	20	9	68	10
14,435	16	21	8	70	11
14,480	19	16	16	73	13
15,126	18	11	15	69	10
15,134	15	14	14	70	11
15,140	14	15	15	70	11
15,168	14	15	4	62	5
15,209	14	16	21	72	12
15,332	19	22	16	77	16
15,761	17	11	14	70	11
15,904	15	17	14	78	17
15,954	13	18	11	67	9
16,014	15	14	14	68	10

There is generally good correlation between density log porosity and sidewall core porosity from 11,482-13,101 feet. Neutron porosity correlates well with sidewall core porosity from 13,103-16,014 feet. There is generally good agreement between density log and sonic log porosities.

Five conventional cores were taken in this well, and the results are summarized in table 8.

Table 8.--Conventional core analysis (summary)

No.	Depth Interval (ft)	Cut	Recov.	Lith.	Porosity Range (%)	Perm. Range (md)	Oil % Pore	Gas % Bulk
1	12,573-12,616	43	43	ss/sh	3.9-12.1	0.03-0.37	-	0.8-3.7
2	12,773-12,791	18	18	ss	13.4-21.2	1.3-291	-	5.6-10.1
3	13,513-13,543	30	30	ss	2.1-15.9	0.01-2.7	-	0.7-9.8
4	14,976-15,006	30	26.5	ss	3.8-18.4	<0.01-62	-	1.1-10.3
5	15,352-15,376	24	24	ss/sh	2.6-6.3	<0.01-0.8	-	0.9-2.5

Core No. 1 has poor correlation with density log porosity, and Core No. 2 correlates well with an average of density and neutron log porosity. Core No. 3 has fair correlation with density log porosity. Core No. 4 has fair correlation with the density log porosity when the hole is in gauge. Porosity as measured on Core No. 5 is lower than the density log porosity which was recorded in an out-of-gauge section of hole.

Results of the HDT survey were recorded on a dipmeter arrow plot from 4,500-12,522 feet. Possible structural anomalies may be present at 4,880, 5,700, 6,180, 6,520, 7,230, 7,470, 8,330, 8,630, 10,450, 10,650, 11,500, and 12,250 feet.

The dip direction and magnitude in the well are as follows:

Interval	Predominant Direction	Magnitude
4,522-4,850	North	1°-6°
4,850-5,700	Southwest	1°-68°
5,700-7,500	East	1°-42°
7,500-8,330	East	1°-13°
8,330-12,522	Northeast	1°-34°

Table 9 summarizes all shows of hydrocarbon encountered in this well.

Table 9.--Shows of hydrocarbon (summary)

Depth Interval	Drilling Break (min/ft)	Sample Description (mud log)	Total Gas bg	Total Gas	Chromat-ograph	Cutt. Gas	Conventional Cores Depth	Ø	k	O_p	G_b	Sidewall Cores Depth	Ø	k	O_p	O_b	G_b	Well Log Interp. Depth	Ø	Sw	Tests
11,490-11,510	4-1	ss, calc	8	75	Not Avail.	1						11,482 11,490 11,492	22 17 17	7 2 2	0 0 0	0 0 0	4 7 5	11,480-11,495	18	47	
11,950-11,960	5-2	ss, calc, trace coal	12	65		1												11,943-11,953	11	61	
12,195-12,290	9-2	ss, calc, abundant coal	15	160		1												12,204-12,292	11	52	
12,340-12,360	7-2	ss, trace coal	20	350		18						12,330-12,342	19-21	7-10	0	0	6-9	12,334-12,346	16	29	
12,390-12,430	8-2	ss, calc	20	80		22												12,379-12,404	5	96	
12,460-12,500	6-3	ss, uncons.	20	220		2						12,460-12,481	13-18	.5-7	0	0	6-7	12,462-12,486	22	48	
12,760-12,890	8-4	ss, coal	10	120		2	12,773-12,791	13-21	1-291	0	6-10	12,770	20	7	0	0	12	12,744-12,778 12,778-12,846	13 6	55 73	DST #11 12,750-777 Recovered 76 BSW, 50,000 ppm Cl^-
12,980-13,025	10-1	ss, sl calc	6	600		2						12,984	21	17	0	0	8	12,973-13,013	20	48	DST #10 12,974-13,013 Recovered 105 BSW

Ø porosity
bg background
k permeability
O_p oil % pore
O_b oil % bulk
G_b gas % bulk
Sw water saturation
BSW barrels of salt water

Table 9.--Shows of hydrocarbon (summary)--Continued

Depth Interval	Drilling Break (min/ft)	Sample Description (mud log)	Total Gas bg		Chromatograph	Cutt. Gas	Conventional Cores Depth	ø	k	O_p	G_b	Sidewall Cores Depth	ø	k	O_p	O_b	G_b	Well Log Interp. Depth	ø	Sw	Tests
13,110- 13,130	10-1	ss, sl calc	12	770		2						13,101 13,103	17 23	3 28	0	0	4 4	13,096- 13,112	16	39	DST #9 13,097- 13,110 No Flow
13,230- 13,250	10-1	ss, sl calc	15	288		2						13,224	21	16	0	0	9	13,202- 13,229	7	66	
13,290- 13,310	14-1	ss, calc	10	65		2												13,271- 13,332	15	56	DST #8 13,270- 13,330 Recovered 65 BSW
15,120- 15,165	6-1	ss, calc, coal	5	800		2						15,126- 15,168	14-18	.4-4	0	0	4-6	15,108- 15,172	11	46	DST #4 15,110- 15,142 No Flow
15,220- 15,235	7-2	ss, sl calc, silic	10	1600		2						15,209	14	.6	0	0	7	15,208- 15,222	15	23	
15,390- 15,400	-	ss, calc	15	375		5	15,352- 15,376	3-6	<.01- .8	0	1-3							15,402- 15,416	15	43	
15,450- 15,500+	12-2	ss, sl calc, coal	25	350		3												15,433- 15,512	11	46	DST #3 15,445- 15,511 Recovered 3'-6' flare

ø porosity
bg background
k permeability

O_p oil % pore
O_b oil % bulk
G_b gas % bulk

Sw water saturation
BSW barrels of salt water

Table 9.--Shows of hydrocarbon (summary)--Continued

Depth Interval	Drilling Break (min/ft)	Sample Description (mud log)	Total Gas bg		Chromatograph	Cutt. Gas	Conventional Cores Depth	ø	k	O_p	G_b	Sidewall Cores Depth	ø	k	O_p	O_b	G_b	Well Log Interp. Depth	ø	Sw	Tests
15,500-(16,087)																		15,562-15,598	10	40	DST #2 15,563-15,600 No flow (acidized)
				354														15,608-15,658	10	49	
																		15,678-15,702	17	52	
												15,761	17	2	0	0	9	15,750-15,786	11	36	
				418														15,822-15,876	12	42	DST #1 15,820-15,875 No flow
				408								15,904	15	1	0	0	7	15,898-15,940	18	63	
				45								15,954	13	.3	0	0	6	15,960-15,973	14	72	
				32								16,014	15	4	0	0	6	16,008-16,032	10	82	
																		16,059-16,079	8	57	

ø porosity
bg background
k permeability

O_p oil % pore
O_b oil % bulk
G_b gas % bulk

Sw water saturation
BSW barrels of salt water

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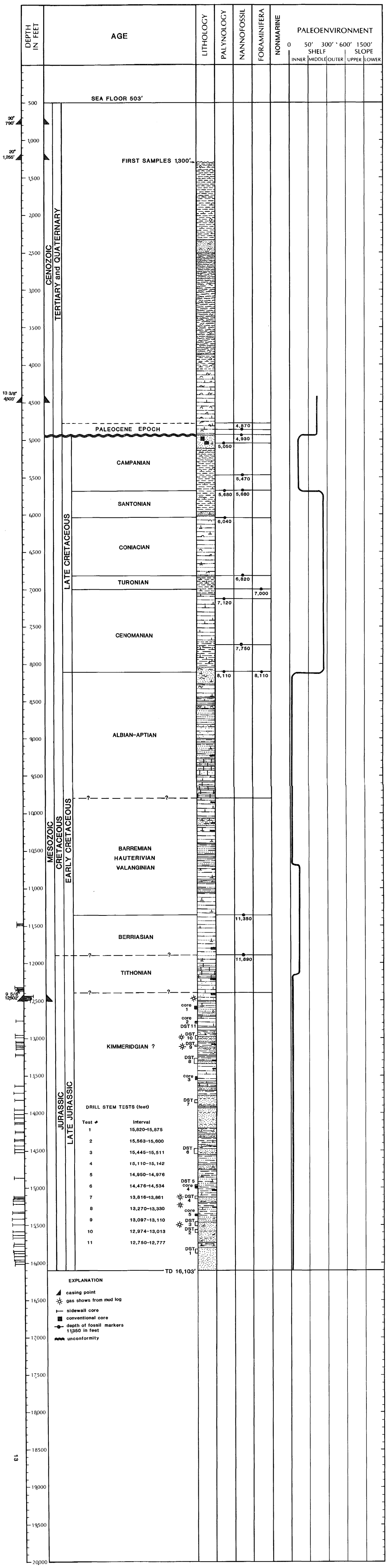

Figure 6.—Lithology, biostratigraphy, and paleobathymetry of the Texaco 598-3 well.