Geologic and Hydrologic Data Collected at Test Hole NC-8, Vega Alta, Puerto Rico

By Jesús Rodríguez-Martínez and Richard A. Scharlach

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CONVERSION FACTORS AND ABBREVIATED WATER-QUALITY UNITS

Multiply	By	To obtain
foot (ft)	0.3048	meter
mile (mi)	1.609	kilometer
square mile (mi^2)	2.590	square kilometer
gallon per minute (gal/min)	0.06308	liter per second

Temperature in degrees Celsius (°C) may be converted to degrees Fahrenheit (°F) as follows: $°F = 1.8\ (°C) + 32$

Abbreviated water-quality units used in this report:

microsiemens per centimeter at 25 degrees Celsius (µS/cm)

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By Jesús Rodríguez-Martínez[1] *and* Richard A. Scharlach[2]

Abstract

Test hole NC-8 was drilled in the municipality of Vega Alta, as part of a study of the aquifers in the Northern Coastal Province of Puerto Rico. The total depth of the test hole was 1,736 feet below land surface. Hydrologic and geologic data collected during drilling included continuous lithologic core, water-quality data, water-level measurements, and estimates of relative yield from the water-bearing zones. Detailed petrological and microfaunal analyses of the core were made to determine the mineralogical content, ages, and paleoenvironments of deposition.

The core recovered from test hole NC-8 indicated that the test hole penetrated five formations ranging in age from middle Oligocene to middle Miocene: the San Sebastián Formation, the Lares Limestone, the Cibao Formation, the Los Puertos Formation, and the Aymamón Limestone. Eight water-bearing units were encountered in NC-8: a water-table aquifer and seven artesian aquifers. The water-table aquifer contains the Los Puertos Formation and the uppermost stratas of the upper member of the Cibao Formation. The artesian aquifers occur in the Quebrada Arenas and Río Indio Limestone members of the Cibao Formation and the Lares Limestone. The water level varied from 79 to 83 feet below land surface in the water-table aquifer and from 11 to 59 feet below land surface in the artesian aquifers. No saltwater was encountered. The specific conductance of the water in the water-table aquifer ranged from 500 to 680 microsiemens per centimeter, while that of water in the artesian aquifers ranged and from 510 to 760 microsiemens per centimeter. The relative yield varied from 75 to 190 gallons per minute in the water-table aquifer and from 10 to 50 gallons per minute in the artesian aquifers. Subsequent to the acquisition of these data, test hole NC-8 was plugged and abandoned.

INTRODUCTION

The Northern Coastal Province in Puerto Rico is part of a northward-thickening wedge of platform carbonates and minor clastics of Oligocene to Holocene age. This carbonate sequence underlies an area of approximately 700 mi^2 along the northern coast of the island from Aguada to Loíza (fig. 1). Extensive dissolution of limestone has created a humid tropical karst characterized by mogotes, sinks, and springs (Monroe, 1976).

Limited geologic and hydrologic data are available for the subsurface coastal region of northern Puerto Rico. As part of a cooperative study between the U.S. Geological Survey and the Puerto Rico Department of Natural Resources, 15 test holes were drilled (fig. 1) to determine the geologic and hydrologic characteristics of the aquifers and confining units of the Northern Coastal Province (Torres-González and Wolansky, 1984).

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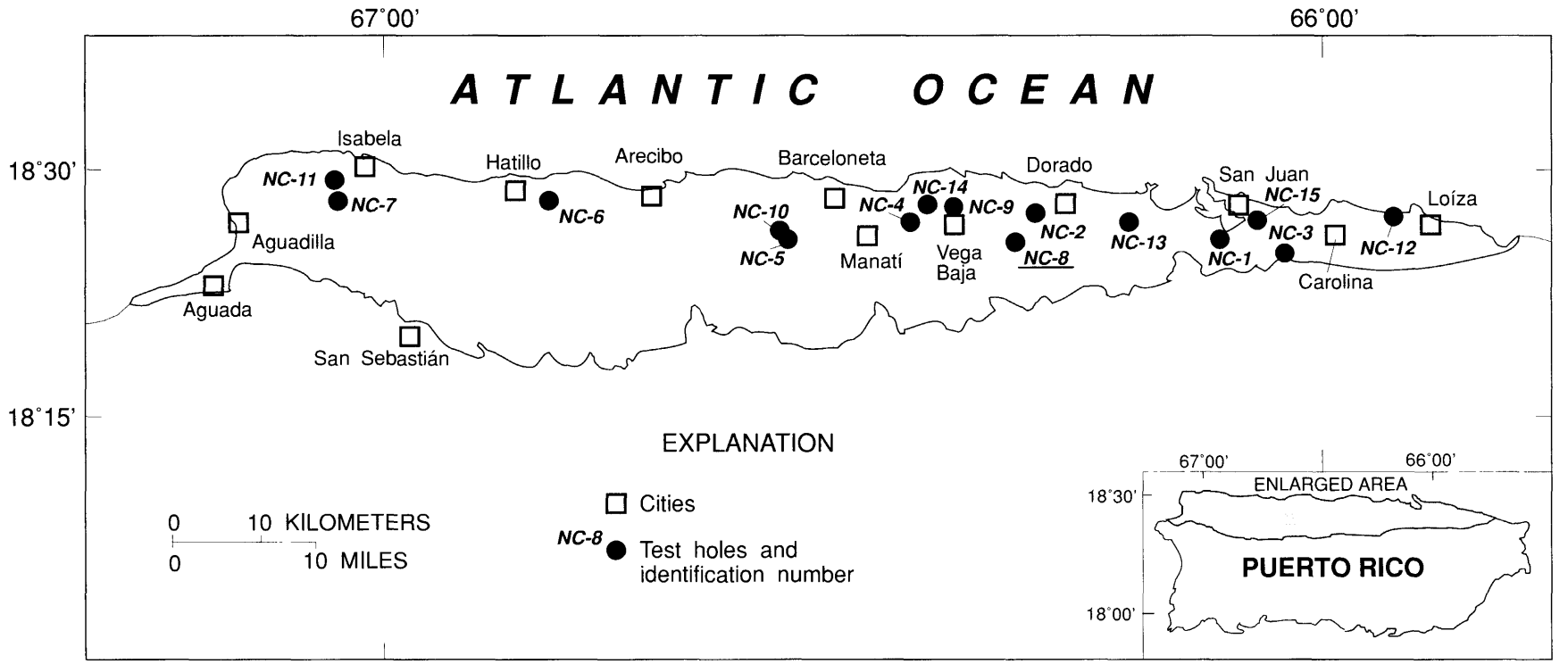

Figure 1. Areal extent of the Northern Coastal Province of Puerto Rico and the location of cities and test holes.

Purpose and Scope

This report presents the geologic and hydrologic data collected at test hole NC-8, drilled in 1986 in the municipality of Vega Alta, located in eastern north-central Puerto Rico. The data collected at the test hole include water levels, aquifer thickness, lithology, relative yield, and specific conductance of water from the major aquifers identified at this site. These data will assist in delineating major north coast hydrogeologic and geologic units and will help in quantifying the direction and rate of ground-water flow in the Northern Coastal Province.

The drilling and coring program was designed to allow the continuous collection of core samples for geologic, hydrogeologic, and paleontologic analyses. Water-level measurements were made and water-quality samples were collected from discrete water-bearing zones.

Location of Study Area

The municipality of Vega Alta is located in the eastern north-central part of Puerto Rico, approximately 15.6 mi west of San Juan. The drilling site is located in the Espinosa sector of the municipality, about 0.31 mi north of Highway 2 (fig. 2).

DATA-COLLECTION METHODS

A drilling method was used that allowed the continuous retrieval of lithologic core, as well as, the collection of water samples, head measurements, and water-flow estimates with minimum interruption of the drilling operations.

Drilling Methods

The test hole was drilled using a hydraulically driven, reverse air drill that uses pressurized air to remove cuttings from the borehole. The drill stem consisted of 20-ft sections of threaded, seamless, double-walled pipe. As drilling progressed, air was forced under high pressure through the annulus between the two walls of the drill stem, forcing formation water and core samples up the center of the drill stem. Cores and water were ejected from the inner pipe into a large cyclone container that dissipate their energy and also served as a sample collector. Test hole NC-8 was plugged and abandoned after core collection and down-hole data acquisition were completed.

Coring

Test hole NC-8 was cored continuously from land surface to the total depth of the test hole. Core samples were retrieved, measured, described, and placed in wooden boxes for preservation and storage at the University of Puerto Rico at Mayagüez. Each core box contains the equivalent of one drill stem length of core; approximately 20 ft. Representative core samples were selected for storage at the U.S. Geological Survey office in San Juan. Core recovery ranged from poor to excellent. Poor core recovery was common in cavernous zones.

Hydrologic Measurements

Water-level measurements were made at depth intervals of approximately 20 ft using either an electric sensor or steel tape. Measurements were made on the inside of the drill pipe before the next section of drill stem was connected. Time restrictions prohibited a full recovery of water levels. Additional water-level measurements were made prior to the start of drilling activity each day and within selected intervals identified on the basis of a noticeable increase in water ejected from the discharge pipe.

Flow measurements were made at the discharge point of the cyclone collector. Although the measurements do not indicate the potential well yield of each of the water-bearing zones, they were made under approximately the same conditions, so that the measured flow reflects the relative yield of each zone. The flow data are therefore referred to as "relative yield." Hydraulic continuity and a sustained minimum flow of 10 gal/min, measured at the discharge point of the cyclone collector, were used as criteria for differentiating water-bearing units. Specific-conductance measurements were also made at the discharge point of the cyclone collector to examine the water quality of water-bearing zones.

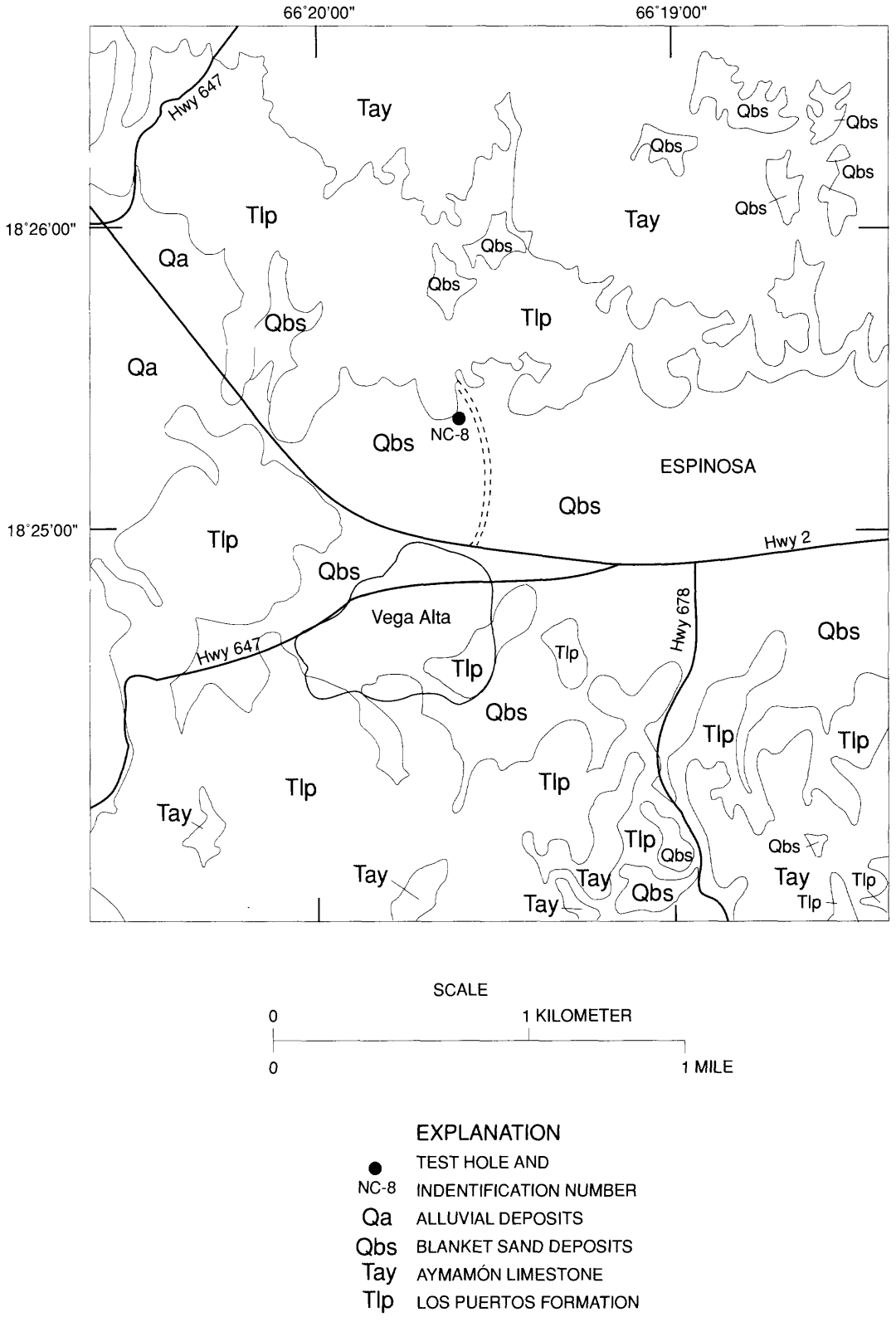

Figure 2. Location of test hole NC-8 and surficial geology of the Vega Alta, Puerto Rico area (Monroe, 1963).

GEOLOGIC AND HYDROLOGIC DATA

In 1980, the rocks that crop out in the Northern Coastal Province were mapped as seven formations by Monroe (1980) on the basis of their lithologic character in the outcrop area. A few years later Seiglie and Moussa (1984) established a new geologic framework for these units using paleontologic data collected from cores, well cuttings, and outcrop samples (fig. 3). This report uses the nomenclature presented by Seiglie and Moussa (1984).

The municipality of Vega Alta is characterized by mogote and ridge karst topography. The surficial geology consists of the Aymamón Limestone, the Los Puertos Formation, and blanket sand deposits of Quaternary age (fig. 2). These lithologic units dip northward with an average slope of five degrees. This northward dip is interrupted by a structural terrace in the vicinity of the town of Vega Alta (Monroe, 1963).

The regional water-table aquifer has been the principal source of ground water in the Vega Alta area. However, it was not until 1960 that large scale development of the water-table aquifer began (Gómez-Gómez and Torres-Sierra, 1988). The hydrogeology of this regional water-bearing unit was described by Gómez-Gómez and Torres-Sierra (1988).

Prior to the drilling of test hole NC-8 in 1986, artesian conditions were suspected to exist in the Cibao Formation and in the Lares Limestone. These units are exposed along the southernmost border of the carbonate platform. No test hole or well in this region had penetrated deeper than the Aymamón Limestone and the Los Puertos Formation prior to 1986. Consequently, the local subsurface facies and hydraulic properties of the Cibao Formation, as well as, those of the Lares Limestone, were largely unknown.

Description of Geologic Units

In descending order, test hole NC-8 penetrated the Aymamón Limestone, the Los Puertos Formation, the Cibao Formation, the Lares Limestone, and the San Sebastián Formation (table 1, at end of report).

The Aymamón Limestone of middle Miocene age, is 74-ft thick (0 to 74 ft in depth) and is dominated by red algae packstone and grainstones. The Aymamón Limestone is underlain by 206 ft of the Los Puertos Formation (74 to 280 ft in depth), composed of the following lithologic intervals: (a) 96 ft (74 to 170 ft in depth) of foraminifera, molluscan, coralline chalky wackestones and packstones; (b) 58 ft (170 to 228 ft in depth) of dolomitic marl and mudstone; and (c) 52 ft (228 to 280 ft in depth) of dolomitized molluscan (tables 1 and 2), foraminifera and red algae packstone with subordinate foraminifera-coralline wackestones and packstone.

The Cibao Formation, 525-ft thick (280 to 805 ft in depth), of Miocene and late Oligocene age underlies the Los Puertos Formation and is divided into the upper member and the undifferentiated Quebrada Arenas Limestone and the Río Indio Limestone Members. The 318-ft thick upper member of the Cibao Formation (280 to 598 ft in depth), consists of three units: (a) 170 ft (280 to 450 ft in depth) of foraminifera-sandy-clayey and locally dolomitic wackestone and packstone with minor claystone; (b) 60 ft (450 to 510 ft in depth) of mollusc and red algae packstone with lithic clasts; and (c) 88 ft (510 to 598 ft in depth) of red interbedded algae packstone, wackestones, and volcaniclastic conglomerates. The underlying undifferentiated Quebrada Arenas Limestone and the Río Indio Limestone Members are 207-ft thick (598 to 805 ft in depth) and consist of a mixed carbonate and terrigenous lithology irregularly alternating between: Lepidocyclina grainstone litharenites, volcaniclastic conglomerates, claystone, and a skeletal-coralline-foraminifera wackestone-packstone and wackestone.

The 533-ft thick Lares Limestone (805 to 1,338 ft in depth) of Oligocene age underlies the Cibao Formation. The Lares Limestone consists of two lithologic units: (a) 305 ft (805 to 1,110 ft in depth) of echinoid-large benthic foraminifera, coral-bearing dolomitic wackestones, red algae and mollusc boundstone with minor, coralline-red algae boundstones and echinoid-large benthic foraminifera packstones; and (b) 228 ft (1,110 to 1,338 ft in depth) of skeletal-echinoid, red algae, large benthic foraminifera, locally clayey wackestones and packstones, with minor coralline packstones and grainstones.

Test hole NC-8 penetrated 398 ft of the San Sebastián Formation (1,338 to 1,736 ft in depth) underlying the Lares Limestone. The San Sebastián Formation is

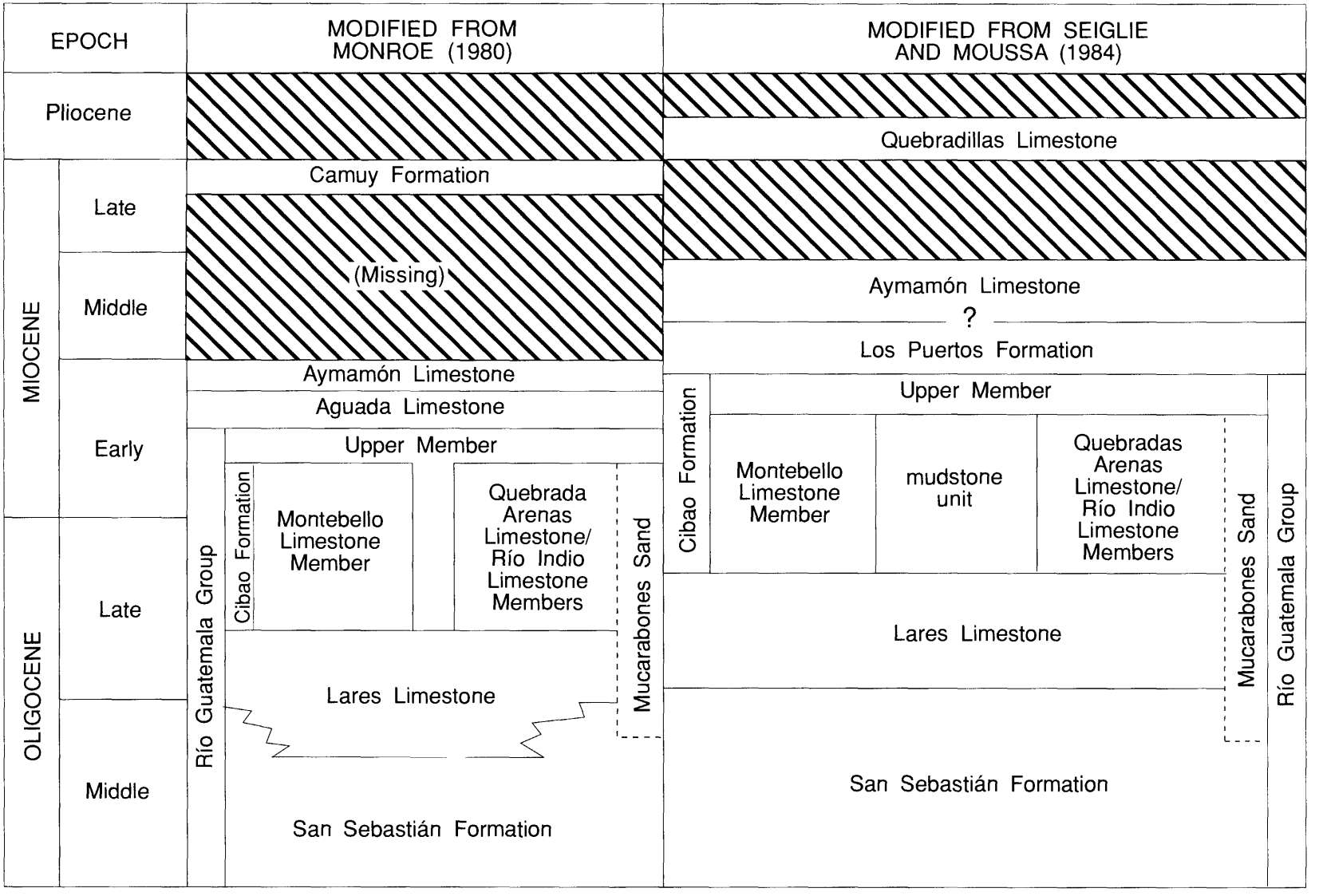

Figure 3. Stratigraphic units comprising the middle Tertiary sequence of the Northern Coastal Province of Puerto Rico.

Oligocene in age and is composed of the following lithologic units: (a) 107 ft (1,338 to 1,445 ft in depth) of foraminifera, red algae, echinoid packstone and wackestone, mollusc-ostracod wackestone and minor calcareous claystone (b) 15 ft (1,445 to 1,460 ft in depth) of interbedded clays and clayey quartz rich, articulate red algae, foraminifera-echinoid, clayey packstones (c) 60 ft (1,460 to 1,520 ft in depth) of dark-green clays, and clay rich oyster-pectinoid pelecypod, mollusc-bryozoan packstone; and (d) 216 ft (1,520 to 1,736 ft in depth) of a variegated claystone becoming slightly calcareous near its top, containing sparse angular quartz, feldspar and volcanic rock fragments.

Description of Water-Bearing Units

Test hole NC-8 penetrated eight water-bearing units: a water-table aquifer and seven artesian aquifers (fig. 4). The uppermost water-bearing unit consists of the Los Puertos Formation and the uppermost stratas of the upper member of the Cibao Formation. This unit extends from the water table (79 ft below land surface) to 358 ft below land surface. A confining unit within the upper member of the Cibao Formation extends from 358 to 504 ft below land surface. Underlying this confining unit is an artesian aquifer in the upper member of the Cibao Formation that extends to a depth of 520 ft (16-ft thick).

A second confining unit contained in the lower part of the upper member and uppermost stratas of the Quebrada Arenas Limestone and Río Indio Limestone Members of the Cibao Formation extends to a depth of 601 ft. The underlying artesian aquifer located in the Quebrada Arenas Limestone and Río Indio Limestone Members extends from 601 to 653 ft. A 77-ft thick interval in the same undifferentiated unit contains three thin artesian aquifers (668 to 680 ft, 693 to 707 ft, and 714 to 731 ft below land surface) and their corresponding confining units. This interval is underlain by a third confining unit also in the Quebrada Arenas Limestone and the Río Indio Limestone Members, extending from 731 to 742 ft. The underlying artesian aquifer, which is 36-ft thick (744 to 780 ft in depth), is contained within the lower part of the Quebrada Arenas Limestone and the Río Indio Limestone Members. The fourth, and lowermost confining unit in the Cibao Formation is 25-ft thick (780 to 805 ft in depth) and is contained in the lowermost strata of the Quebrada Arenas Limestone and the Río Indio Limestone Members of the Cibao Formation. The underlying and basal artesian aquifer is 450-ft thick (805 to 1,255 ft in depth) and is contained within the Lares Limestone.

Specific-conductance measurements of water from NC-8 varied from 500 to 680 µS/cm in the water-table aquifer and from 510 to 760 µS/cm in the artesian zones (fig. 4, table 2). Water levels within the aquifers varied from 79 to 83 ft below land surface in the water-table aquifer, and from 11 to 59 ft below land surface in the artesian aquifers (fig. 4, table 2). Estimates of relative yield during drilling ranged from 75 to 190 gal/min in the water-table aquifer and from 10 to 50 gal/min in the artesian aquifers (fig. 4, table 2).

SUMMARY

This report presents data collected from test hole NC-8, drilled in 1986, in the municipality of Vega Alta, Puerto Rico. Test hole NC-8 was drilled to determine the depth, thickness, and hydraulic properties of the water-table aquifer and artesian aquifers of this area, as part of a study of the regional aquifer system in the Northern Coastal Province of Puerto Rico. Data collected from this test hole include core lithology, water levels, specific conductance of water, and relative yields.

Test hole NC-8 penetrated five formations ranging in age from middle Oligocene to middle Miocene. From deepest to shallowest, the formations penetrated were the San Sebastián Formation, the Lares Limestone, the Cibao Formation, the Los Puertos Formation, and the Aymamón Limestone.

Eight water-bearing units were penetrated by test hole NC-8: a water-table aquifer and seven artesian aquifers. Water levels varied from 79 to 83 ft below land surface in the water-table aquifer, and from 11 to 59 ft below land surface in the artesian aquifers. The relative yield ranged from 75 to 190 gal/min in the water-table aquifer and from 10 to 50 gal/min in the artesian aquifers. The specific conductance ranged from 500 to 680 µS/cm in the water-table aquifer and from 510 to 760 µS/cm in the artesian aquifers. Test hole NC-8 was plugged and abandoned, when data collection was completed.

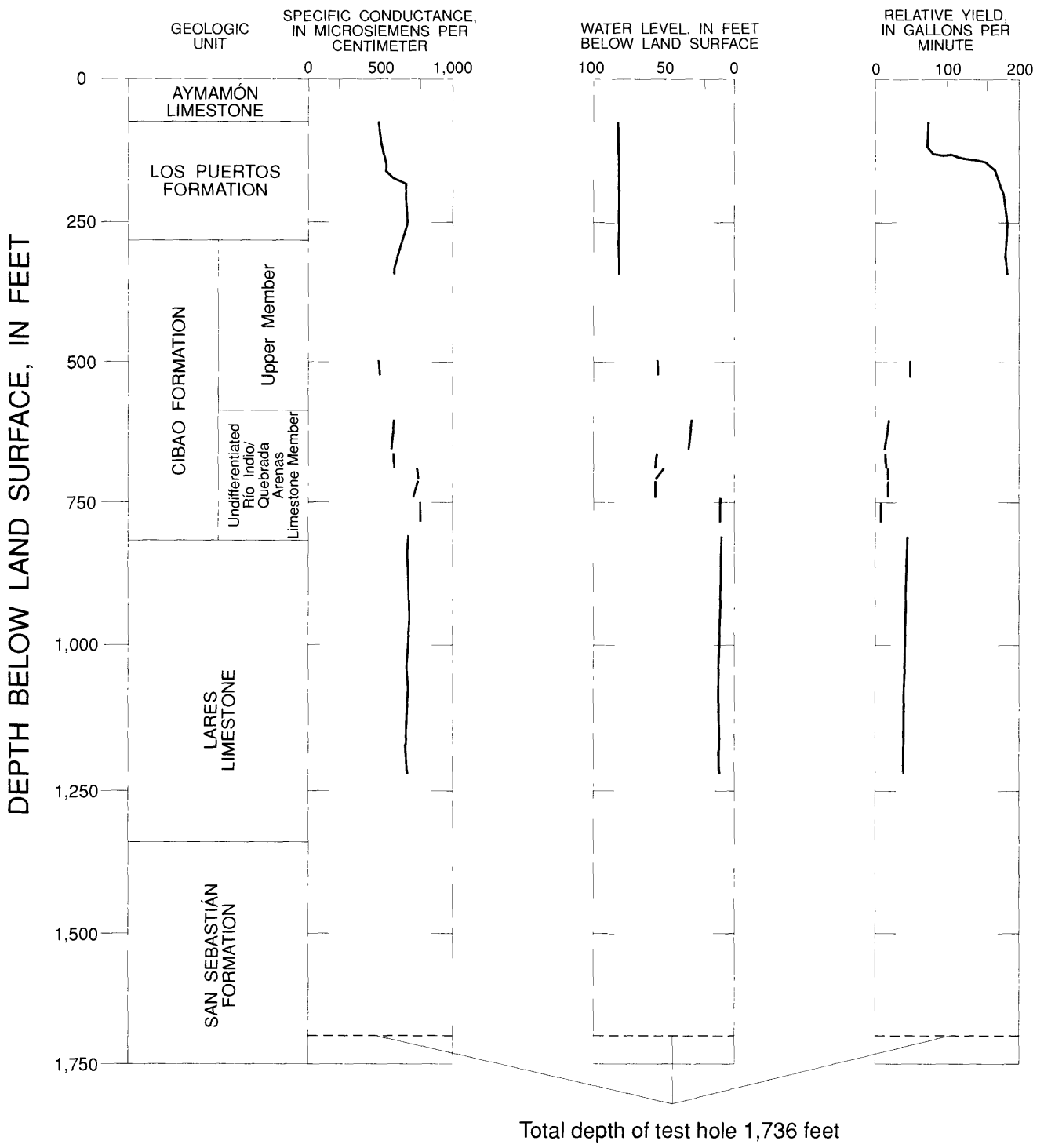

Figure 4. Geologic units, specific conductance, water levels, and relative yield at test hole NC-8, Vega Alta, Puerto Rico.

Table 2. Selected hydrologic data from test hole NC-8, Vega Alta, Puerto Rico

Depth below land surface (feet)	Water level below land surface (feet)	Specific conductance (microsiemens per centimeter at 25) degrees Celsius	Yield (gallons per minute)
	Water-Table Aquifer		
79	79	500	75
170	80	500	165
200	80	650	180
250	80	680	190
300	82	625	190
358	80	585	188
	First Artesian Aquifer		
504	59	510	50
505	59	510	50
520	59	550	50
	Second Artesian Aquifer		
601	34	560	20
653	34	560	15
	Third Artesian Aquifer		
668	59	580	15
680	59	580	15
	Fourth Artesian Aquifer		
693	52	750	10
707	59	750	10
	Fifth Artesian Aquifer		
714	59	750	15
731	59	760	15
	Sixth Artesian Aquifer		
742	11	760	12
780	11	760	12
	Seventh Artesian Aquifer		
805	11	700	45
1,225	11	700	45

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Table 1. Description of lithologic core of test hole NC-8, Vega Alta, Puerto Rico

[(10YR8/4): Color code according to the Rock-Color Chart of the Geological Society of America, 1951]

Lithologic Description	Depth, in feet below land surface
Miocene Series	
Aymamón Limestone	
Packstone, grayish-orange (10 YR 8/4); hard, crystalline; fossils include red algae and foraminifera. Clay (soil), reddish-brown.	0 - 30
Grainstone, pale yellow-orange (10 YR 8/6), variably chalky to hard, crystalline; fossils include peloids, articulate red algae, molluscs and echinoids. Porosity: present at 40 to 50 feet, but filled or partly filled with reddish-brown clay or silt.	30 - 74
Los Puertos Formation	
Packstone, pale yellowish-orange (10 YR 8/6), very pale orange (10 YR 8/2), variable chalky and crystalline, hard; fossils include corals, molluscs, foraminifera, Kuphus; large vugs present at 110 to 115 feet filled or partially filled with reddish-brown clay/silt. Porosity: low-medium; moldic; and intraparticle.	74 - 155
Packstones-rudstones, grayish-orange (10 YR 7/4); fossils include branching corals, oysters, echinoids and a few small corals. Porosity: low-medium; moldic.	155 - 170
Marl; mudstone, yellowish-gray, dolomitic, bioturbated; burrows with pyrite outlines. Porosity: low; interparticle; intercrystalline.	170 - 228
Packstone; lesser wackestone; yellowish-gray (5 Y 8/1), dolomitic; fossils include molluscs, foraminifera (soritids, miliolids, and Amphistegina), and coralline red algae. Porosity: high-medium moldic, interparticle and intercrystalline (abundant molluscan and branching coral molds).	228 - 252
Wackestone; packstone, yellowish-gray (5 Y 8/1), light gray (N7), slightly sandy quartz; minor burrowing; some nearly pure dolomite layers; fossils include Halimeda, foraminifera (miliolids, soritids, peneroplids), and coral. Porosity: medium-high moldic, interparticle and intercrystalline.	252 - 280
Cibao Formation	
upper member	
Wackestone, greenish-gray (5 YR 6/1), quartz sandy; fossils include corals, molluscs, foraminifera (soritids and miliolids). Porosity: medium-high; moldic; interparticle; intercrystalline.	280 - 311

Table 1. Description of lithologic core of test hole NC-8, Vega Alta, Puerto Rico--Continued

Lithologic Description	Depth, in feet below land surface
Claystone, yellow-brown.	311 - 324
Packstone, light-gray (N7), skeletal, sandy quartz; grades to skeletal sandstones locally.	324 - 342
Wackestone, greenish-gray (5 GY 6/1), sandy quartz; fossils include foraminifera (soritids, miliolids), molluscs (including high-spired gastropods); variably dolomitic. Boundstone, same color; red algae most abundant fossil. Porosity: medium-high; moldic; interparticle; intercrystalline.	342 - 358
Claystone, olive, yellow-gray, yellow.	358 - 382
Wackestone, light greenish-gray (5 GY 8/1), quartz sandy; regularly interbedded with clays; fossils include soritids, miliolids, and gastropods. Porosity: low.	382 - 450
Packstone, yellowish-gray (5 Y 8/1), dusky yellow (5 Y 6/4); often bearing lithoclasts; fossils include molluscs, foraminifera, red algae, branching coral fragments, cyclostome broyzoans, and Halimeda. Porosity: low-medium; moldic; intraparticle; interparticle.	450 - 510
Wackestone; packstone, clayey sandy quartz; fossils include fine articulate red algae and coalified plant remains (570-580 feet). Porosity: low; interparticle; moldic. Clays, olive, red, yellow, and purple. Conglomerates, yellowish-gray (5 Y 8/1), grayish-yellow (5 Y 8/4), poorly sorted; lithic and quartzose. Sands; well-rounded volcanic rock fragments at 510 to 515 feet, 527 to 531 feet, 535 to 540 feet, and 570 to 575 feet.	510 - 598
Undifferentiated Quebrada Arenas and Río Indio	
Limestone Members	
Grainstone, medium light gray(N6); locally grades to quartz-lithic arenites; fossils include Lepidocyclina, Miogypsina, miliolids, echinoids and articulate red algae; a thin silty layer contain blackened organic plant remains and thin branching bryozoans. Porosity: low to medium depending on cementation; moldic; interparticle.	598 - 655
Clay, green-gray, calcareous.	655 - 668
Conglomeritic-rudstone, light gray (N7), yellowish-gray (5 Y 8/1), lithic; coral, red algae, and benthic foraminifera; crustose red algae coated volcanic rock and coral fragments in a micritic matrix containing large benthic foraminifera and oysters. Porosity: medium; moldic; interparticle; intraparticle.	668 - 680

Table 1. Description of lithologic core of test hole NC-8, Vega Alta, Puerto Rico--Continued

Lithologic Description	Depth, in feet below land surface
Grainstone, yellowish-gray (5 Y 8/1); fossils include molluscs, large benthic foraminifera, miliolids and fine articulated red algae; fines and muddies upward into a fine-grained, dolomitic wackestone; larger skeletal grains have a blackened coating which gives rock a speckled appearance. Porosity: low-medium; interparticle; intercrystalline; moldic.	680 - 710
Clays, greenish-gray.	710 - 714
Packstones; grainstones; yellowish-gray (5 Y 8/1); lower half of sequence is quartz and lithic; fossils include Lepidocyclina, Heterostegina, Amphistegina and encrusting foraminifera, Victoriella, Carpinteria, and molluscs; rhodolites common in the top 5 feet. Porosity: medium to high; interparticle; moldic.	714 - 731
Clays, yellowish-gray (5 Y 8/1), brown-black to dark-gray, silty; thin layers of foraminifera limestones.	731 - 743
Wackestone-packstone, yellowish-gray (5 Y 8/1), slightly dolomitic; fossils include large benthic foraminifera, red algae, echinoids and bryozoans; grades up to grainstone, lithic and sandy quartz. Porosity: medium-high.	743 - 770
Rudstone, yellowish-gray (5 Y 8/1); fossils include corals, red algae, large benthic foraminifera, molluscs, echinoids, and bryozoans. Porosity: medium-high; interparticle; intraparticle; moldic; slightly reduced by coarse spar cement.	770 - 782
Sands; silts; clays; black to light gray (N6); sands are litharenites containing an estimated 60 percent volcanic rock fragments and quartz; skeletal grains include articulate red algae, molluscs (leached and later spar replaced) and echinoid parts; lesser components include ostracods, Halimeda, and phosphatic fish scales; grains rimmed with isopachus marine cement. Porosity: low moldic; blocky spar filled remaining pores.	782 - 805
Oligocene Series	
Lares Limestone	
Rudstone, yellowish-gray (5 Y 7/2), coralline; rhodolitic clasts in dolomitic clayey wackestone matrix; fossils in matrix include compact echinoid spines and molluscan fragments. Porosity: low (clay rich zones); medium; moldic; intercrystalline (dolomitic zones).	805 - 820

Table 1. Description of lithologic core of test hole NC-8, Vega Alta, Puerto Rico--Continued

Lithologic Description	Depth, in feet below land surface
Packstone, yellowish-gray (5 Y 8/1 and 5 Y 7/2), dolomitic, clayey; fossils include corals, red algae, large benthic foraminifera and molluscs; black larger skeletal grains give rock a speckled appearance. Porosity: low-medium; intraparticle; moldic; interparticle. Dolomite, same color as packstone; ranges from nearly pure to minor amounts occurring as rhombehedrons along clayey seams (table 2). Porosity: high-medium; moldic; intercrystalline.	820 - 877
Packstone-grainstone, yellowish-gray (5 Y 8/1 and 5 Y 7/2); sparsely cemented; cross-bedded near bottom; fossils include red algae, molluscs, large benthic foraminifera, and echinoids. Porosity: medium-high; interparticle; intraparticle; moldic.	877 - 905
Wackestone, light olive-gray (5 Y 8/1), dolomitic; fossils include large benthic foraminifera, red algae, and molluscs. Porosity: medium-high; intercrystalline; interparticle.	905 - 915
Boundstone, yellowish-gray; geopetal structures common; coralline and red algae, in a molluscan, echinoid, and articulate red algae wackestone matrix. Porosity: medium; moldic; shelter.	915 - 935
Wackestone; packstone; grayish-yellow-green (5 GY 8/1 and 5 Y 7/2), fine sandy quartz, and plagioclase, dolomitic; vertical and horizontal burrows; wavy laminations common; minor pyrite; fossils include red algae, molluscs, and large benthic foraminifera. Porosity: medium-low; intercrystalline; interparticle; intraparticle.	935 - 985
Wackestone; packstone; grayish-yellow-green (5 GY 8/1 and 5 Y 7/2), matrix commonly neomorphosed micrite (microspar). Porosity: low-medium; moldic; intraparticle; interparticle.	985 - 1,015
Wackestone; packstone; light olive-gray (5 Y 6/1), dolomitic, bioturbated, clay rich, slightly glauconitic; fossils include large benthic foraminifera, echinoid spines, articulate and crustose red algae, pelecypods, Lepidocyclina and Heterostegina, pectenoid pelecypods (in thin clay layers). Porosity: low-medium, locally high; intercrystalline; moldic.	1,015 - 1,080
Packstone, light olive-gray (5 Y 6/1), coarse grained; fossils include molluscs, large benthic foraminifera, echinoids and rare intraclasts. Porosity: low; intraparticle; moldic; shelter.	1,080 - 1,110
Wackestone; packstone, light olive-gray (5 Y 6/1), fine grained, dolomitic; minor clay; fossils include broken fragments of benthic foraminifera, echinoids, and pelecypods. Porosity: medium; intercrystalline; interparticle.	1,110 - 1,145

Table 1. Description of lithologic core of test hole NC-8, Vega Alta, Puerto Rico--Continued

Lithologic Description	Depth, in feet below land surface
Boundstone, light olive-gray (5 Y 6/1), yellowish-gray (5 Y 7/2), digitate rhodolites composed of red algae and encrusting foraminifera in large benthic foraminifera wackestone and packstone matrix; some non-rhodolitic layers; common bioclasts include Lepidociclyna, Miogypsina, and Heterostegina; less commonly miliolids and other smaller benthic foraminifera, pelecypods, echinoids and articulate red algae. Porosity: medium-low; interparticle; moldic.	1,145 - 1,180
Wackestone-packstone, light olive-gray (5 Y 6/1); dolomitic micritic matrix; fossils include coralline, branching, and crustose red algae, large benthic and encrusting foraminifera. Porosity: medium; moldic; interparticle; intercrystalline.	1,180 - 1,205
Wackestone, light olive-gray (5 Y 6/1); some non-rhodolitic layers; common bioclasts include Lepidociclyna, Miogypsina, and Heterostegina; less commonly miliolid and other smaller benthic foraminifera, pelecypods, echinoids, and articulate red algae.	1,205 - 1,220
Packstone-grainstone, light olive-gray (5 Y 7/2), yellowish-gray (5 Y 6/10); fossils include branching red algae, large benthic foraminifera (Lepidocyclina and Heterostegina), echinoids and corals. Porosity: medium-low; moldic; interparticle; intraparticle; much original porosity by late calcite spar cementation.	1,220 - 1,255
Packstone-grainstone, light olive-gray (5 Y 7/2); same yellowish-gray (5 Y 6/10) but more clay rich. Wavy clayey partings common. Porosity: low; interparticle; intraparticle.	1,255 - 1,280
Wackestone; packstone, light olive-gray (5 Y 6/1), greenish-gray (5 GY 6/1), clay rich, bioturbated; microstylolites; fossils include large benthic foraminifera, echinoids, corals, and pelecypods. Porosity: low; interparticle; intraparticle.	1,280 - 1,338
San Sebastián Formation	
Claystone, gray-green (5 GY 6/1), calcareous.	1,338 - 1,343
Packstone-grainstone, light olive-gray (5 Y 7/2); same yellowish-gray (5 Y 6/10) with slightly higher clay content.	1,343 - 1,365
Packstones, greenish-gray (5 GY 6/1), clayey; thin clay-line wavy laminations-microstylolites common; minor sparry calcite and pyrite cement; fossils include echinoids, molluscs, red algae, and foraminifera (Lepidocyclina, miliolids, and large encrusting foraminifera). Porosity: low; moldic; intraparticle; slightly reduced.	1,365 - 1,386

Table 1. Description of lithologic core of test hole NC-8, Vega Alta, Puerto Rico--Continued

Lithologic Description	Depth, in feet below land surface
Limestone, coralline; clay-rich; molluscs, red algae-ostracode-wackestone matrix; fossils include coral heads (recrystallized often with borings), oysters, and bryozoans; branching coral thicket at 1,397 feet. Porosity: low; interparticle.	1,386 - 1,445
Packstone, dark greenish-gray (5 GY 6/1); approximately 50 percent micrite matrix; clay and sandy quartz; glauconitic and phosphatic grains locally abundant; wavy clay laminations common; interbedded with claystone; fossils include articulate red algae, foraminifera, and echinoids. Porosity: low; moldic; interparticle; fine; slightly reduced by calcite and glauconite cements.	1,445 - 1,460
Packstone, dark greenish-gray (5 GY 6/1); sandy quartz, wavy clay-rich laminations; glauconite common in upper 20 feet; fossils include oysters, pectenoid pelecypods, echinoid plates, spines, and miliolids. Porosity: low; claystone, dark greenish-gray (5 GY 6/1), bearing branching red algae.	1,460 - 1,520
Claystones, grayish-olive-green (5 GY 4/2), red-brown, yellow-brown, purple calcareous; locally fine partings of black, organic matter with associated pyrite present; fossils include scattered thin-shelled pelecypod fragments, oysters, high-spired gastropods and ostracods. Porosity: low.	1,520 - 1,736

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