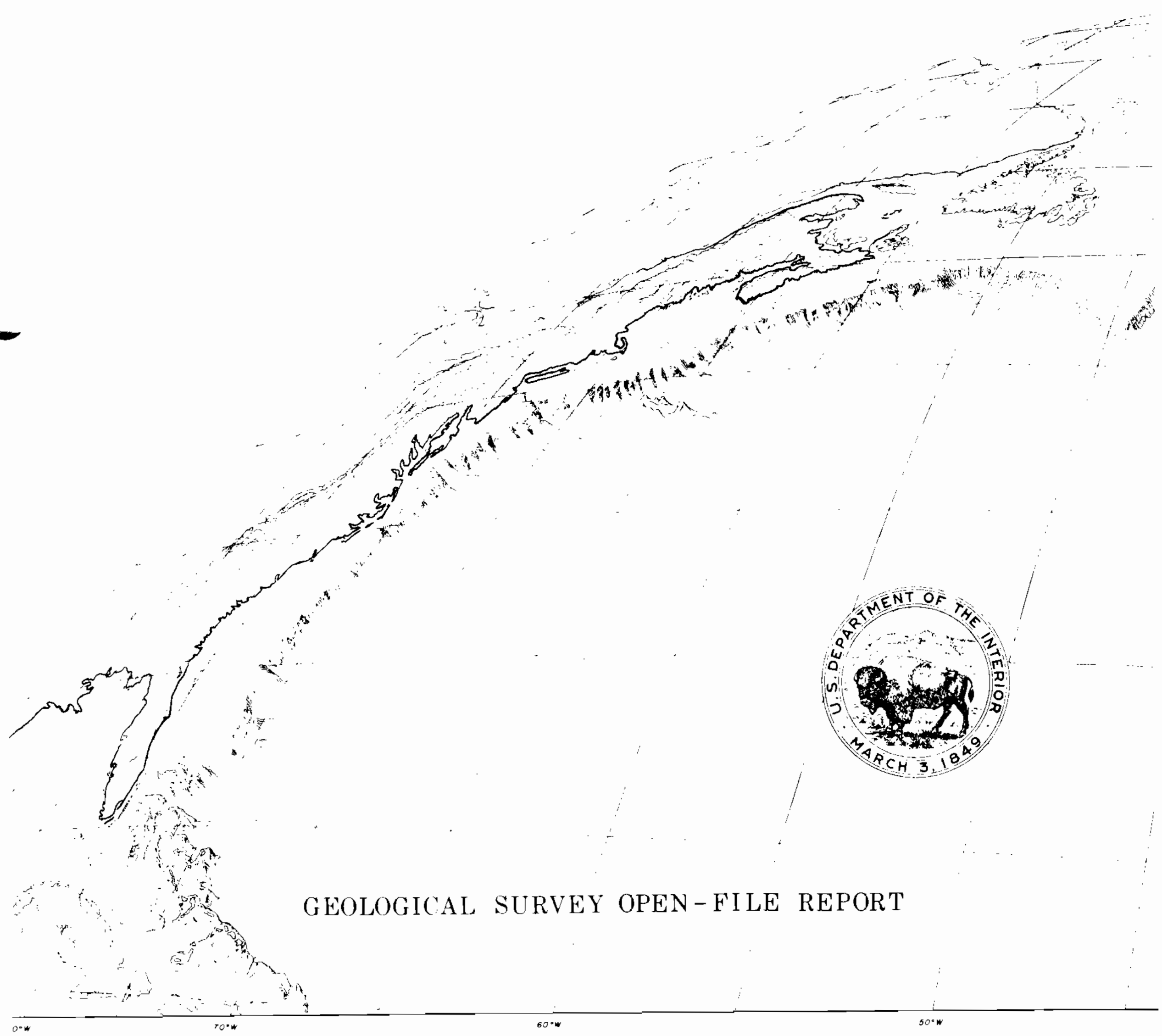
GEOLOGIC FRAMEWORK AND PETROLEUM POTENTIAL OF THE ATLANTIC COASTAL PLAIN AND CONTINENTAL SHELF

1967



GEOLOGICAL SURVEY OPEN-FILE REPORT

UNITED STATES DEPARTMENT OF THE INTERIOR

GEOLOGICAL SURVEY

GEOLOGIC FRAMEWORK AND PETROLEUM POTENTIAL OF THE ATLANTIC COASTAL PLAIN AND CONTINENTAL SHELF

By

John C. Maher

With a section on STRATIGRAPHY

By John C. Maher and Esther R. Applin

Open-file report

1967

This report is preliminary
and has not been edited or
reviewed for conformity with
Geological Survey standards

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Geologic framework and petroleum potential of the Atlantic Coastal Plain and Continental Shelf

By John C. Maher

Abstract

The Atlantic Coastal Plain and Continental Shelf of North America is represented by a belt of Mesozoic and Cenozoic rocks, 150 to 300 miles wide and 2,400 miles long, extending from southern Florida to the Grand Banks of Newfoundland. This belt of Mesozoic and Cenozoic rocks encompasses an area of about 400,000 to 450,000 square miles, more than three-fourths of which is covered by the Atlantic Ocean. The volume of Mesozoic and Cenozoic rocks beneath the Atlantic Coastal Plain and Continental Shelf exceeds 450,000 cubic miles, perhaps by a considerable amount. More than one-half of this is seaward far enough to contain marine source rocks in sufficient proportion to attract exploration for oil. A larger fraction, perhaps three-quarters of the volume, may be of interest in exploration for gas.

The Coastal Plain consists of land between the crystalline piedmont of the Appalachian System and mean low-tide from southern Florida to the tip of Long Island plus a few small offshore islands and the Cape Cod Peninsula. This is an area of more than 100,000 square miles.

The Continental Shelf extends from mean low-tide to the break marking the beginning of the continental rise, which is somewhat less than 600 feet in depth at most places. It is a gently sloping platform, about 350,000 square miles in area, that widens from less than 3 miles off southern Florida to about 285 miles off Newfoundland.

The Blake Plateau occupies an area of about 70,000 square miles between the 500 and 5,000-foot bottom contours from the Cape Hatteras vicinity to the northernmost bank of the Bahamas. It has a gentle slope with only minor irregularities and scattered patches of Recent sediments.

Both gravity and magnetic anomalies along the Atlantic Coast reflect primarily compositional differences at considerable depths in the earth's crust, but are related to some extent to the structure and composition of the Coastal Plain sedimentary rocks and shallow basement. Four alternating belts of predominantly positive and predominantly negative Bouguer gravity anomalies extend diagonally across the region from southwest to northeast. These correspond roughly with the continental rise and slope, the Continental Shelf and Coastal Plain, the Appalachian Mountain System front, and the Piedmont Plateau-Blue Ridge-Appalachian Basin region.

Long, linear, southwesterly magnetic anomalies trend roughly parallel to the Appalachian Mountain System and the Shelf edge. These trends are interrupted along the 40th parallel, about 50 miles south of New York, by a linear anomaly, suggesting a transcurrent fault, more or less alined with a string of seamounts extending down the continental rise to the abyssal plain. The trends parallel to the Appalachians terminate in Florida against a southeasterly magnetic trend thought by some to represent an extension of the Ouachita Mountain System. One large anomaly, known as the slope anomaly, parallels the Shelf edge north of Cape Fear and seemingly represents the basement ridge located previously by seismic methods. Recently the suggestion has been made that the basement ridge along the Atlantic Shelf is a buried, quiescent island arc and that the slope anomaly reflects intrusive and extrusive phases of volcanism during the active tectonic development of the island arc.

Structural contours on the basement rocks, as drawn from outcrops, wells, and seismic data, parallel the Appalachian Mountains except in North and South Carolina, where they bulge seaward around the Cape Fear arch, and in Florida, where the deeper contours follow the peninsula. The basement surface is relatively smooth and dips seaward at rates ranging from 10 feet a mile inland to as much as 120 feet a mile near the ocean. A decided steepening of the slope is apparent below a depth of 5,000 feet in most of the area. The principal structural features are the Southwest Georgia embayment, South Florida embayment, Peninsular arch, Bahama uplift, Southeast Georgia embayment, Cape Fear arch, Salisbury embayment, Baltimore Canyon trough, and Georges Bank trough.

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C

Triassic, Cretaceous, and Tertiary rocks crop out roughly parallel to the present Atlantic coastline. Triassic outcrops are confined to scattered down-faulted basins within the piedmont. Lower Cretaceous outcrops are recognized in the Salisbury embayment of New Jersey, Delaware, Maryland, and Virginia, and may be represented farther south as thin clastic beds mapped with the basal Upper Cretaceous. Upper Cretaceous rocks crop out almost continuously along the Fall Line from eastern Alabama to the north flank of the Cape Fear arch in North Carolina, and from Virginia to New York. Tertiary rocks crop out in broad patterns throughout the Coastal Plain except on the Cape Fear arch and where masked by a veneer of alluvial deposits.

The Cretaceous and Tertiary rocks exposed from southern Georgia northward to Long Island are mainly continental clastics interspersed with some thin lignitic layers and marl beds. Seaward, these rocks become marine in character and thicken to more than 10,000 feet at the coastline. Cretaceous rocks do not crop out in southern Georgia and Florida, and Tertiary rocks are only partially exposed. Both are dominantly marine carbonates in the subsurface and exceed 15,000 feet in thickness in the Florida Keys and Bahama Islands.

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D

The oldest rock recovered from the sea bottom along the Atlantic Coast has come from the Paleozoic granite pinnacles at a depth of about 5 fathoms on Cashes Ledge near the middle of the Gulf of Maine. Cretaceous rocks of Taylor and Navarro age have been dredged from the east walls of Oceanographer and Gilbert Canyons off Georges Bank and rocks of Woodbine age from the escarpment of the Blake Plateau opposite Cape Kennedy. In addition, cobbles of chalk containing Cretaceous Foraminifera have been found in a core from the floor of Northeast Providence channel, 11,096 feet beneath the sea between the Bahama Islands, and reworked Cretaceous Foraminifera have been identified in a core of coarse glauconitic sand on the continental rise, 155 miles southwest of Cape Hatteras. Short cores and dredgings of Tertiary rocks, mostly Late Eocene (Jackson) and younger in age, have been recovered at more than three dozen localities concentrated for the most part between Georges Bank and the Hudson Canyon, and in the Blake Plateau-Bahama Banks region. Pleistocene silts and clays have been found in many cores, and gravel and boulders of glacial origin have been dredged north of New York City.

E

Shoals, artesian submarine springs, and underwater photographs have provided some stratigraphic and structural information about the upper strata of the Shelf. Marl of lower Miocene age is reported to crop out on the fishing banks known as "Black Rocks" off the coast of North and South Carolina. An oceanic spring in the Ocala Limestone of upper Eocene age has been charted about $2\frac{1}{2}$ miles east of Crescent Beach near St. Augustine, Florida. Others have been reported along the east coast near Cape Kennedy. An interesting limestone outcrop of unknown age has been photographed at a depth of 6,000 feet in the Tongue of the Ocean of the Bahama Islands.

A test hole has been drilled on the Shelf in 54 feet of water about 10 miles off Savannah, Georgia. The test hole, which stopped in the Ocala Limestone of upper Eocene age, revealed that rather uniform thicknesses of Oligocene, lower Miocene, and middle Miocene strata extend from shore seaward for at least 10 miles, that the upper Miocene rocks and the Pleistocene and Recent deposits decrease in thickness seaward, and that only the Oligocene rocks exhibit a pronounced facies change -- one from carbonates to clastics in a seaward direction.

F

Test holes located 27 to 221 miles off Jacksonville, Florida, indicate that Paleocene beds probably continue from the Coastal Plain to the edge of the Blake Plateau, and are exposed as sea bottom along the lower part of the slope. The Eocene, Oligocene, and Miocene beds appear to be prograded seaward beneath the outer Shelf and upper slope, absent from the lower slope, and greatly thinned on the Plateau. The absence of Eocene, Oligocene, Miocene, and post-Miocene deposits from the lower slope corresponds rather closely to the axis of maximum velocity of the Gulf Stream. This lends support to the theory that sometime during early Tertiary time the Gulf Stream began flowing through the Straits of Florida, the Stream's velocity prevented sedimentation on the ancient shelf except near the coast, and the ancient shelf subsided slowly to form the Blake Plateau.

The subsurface correlations of the Mesozoic and Cenozoic rocks beneath the Coastal Plain are traced along eight cross sections. One cross section extends subsurface correlations from the marine carbonate facies beneath the Florida Keys northward into the mixed marine and continental clastic facies beneath Long Island. The others trace units of the dominantly clastic outcrops downdip into marine facies along the coast.

The pre-Mesozoic basement rocks beneath the Coastal Plain are primarily igneous and metamorphic rocks of Precambrian and Paleozoic age. Some Paleozoic sedimentary rocks ranging from Early Ordovician to Middle Devonian in age are present in the basement in northern Florida.

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Triassic rocks(?), which consist of red arkose, sandstone, shale, tuff, and basalt flows, in places intruded by diabase, are present in down-faulted basins in the basement. Rocks of Upper Jurassic or Lower Cretaceous (Neocomian) age, undifferentiated, are present beneath southern Florida. There the sequence, as much as 1,100 feet thick, consists principally of limestone, dolomite, and anhydrite with a marginal clastic facies at the base where it rests on igneous basement. Equivalent rocks about 900 feet thick are present at Cape Hatteras, North Carolina, and extend northward along the coast into New Jersey.

In Florida, the Lower Cretaceous rocks, subdivided into rocks of Trinity, Fredericksburg, and Washita age, are dominantly carbonates and exceed 6,700 feet in thickness beneath the Florida Keys. Northward along the coast, the rocks wedge out on the Peninsular arch, then reappear as a thin clastic unit across Georgia and South Carolina. They are missing from the higher parts of the Cape Fear arch in North Carolina but are present on the east flank as a thickening wedge of mixed clastic and carbonate rocks more than 2,800 feet thick at Cape Hatteras and 2,600 feet thick in Maryland. Lower Cretaceous rocks probably extend into northern New Jersey but do not reach Long Island.

Upper Cretaceous rocks, which can be subdivided into rocks of Woodbine, Eagle Ford, Austin, Taylor, and Navarro age, are about 1,200 to 3,000 feet thick in wells along the coast. In Florida, they are almost totally marine carbonates. These grade northward along the coast into mixed marine carbonates and clastics in North Carolina, and then into marine and continental clastics beneath Long Island.

Tertiary rocks and thin Quaternary deposits are present along the coast. The thickness of Tertiary rocks along the coast ranges from 4,300 feet in southern Florida to 130 feet on Long Island. In general, the Tertiary rocks are dominantly carbonates along the southern half of the Atlantic coastline, and mostly sandstone and limy shale along the northern half.

Upper Jurassic and Lower Cretaceous rocks offer the most promising prospects for oil and gas production in the Atlantic coastal region. Their combined thickness probably exceeds 5,000 feet offshore in the Baltimore Canyon trough, in the Southeast Georgia embayment, and beneath the Blake Plateau and Bahama Islands. Marine beds generally regarded as potential sources of petroleum are predominant, and the environment of their deposition, at least in the southern areas, probably favored reef growth. Thick, very porous, salt-water bearing reservoirs, both sandstone and carbonate, are numerous. Important unconformities are present not only at the top but within the sequence. Three small accumulations of oil have been found in Lower Cretaceous rocks of southwestern Florida.

9.1267

Rocks of Upper Cretaceous age have good possibilities for oil and gas production beneath the Continental Shelf, but only fair possibilities, chiefly for gas, in the Coastal Plain. Although the thickness of these rocks does not exceed 3,500 feet onshore and may be only a few thousand feet more beneath the Shelf, the beds are buried sufficiently beneath the Tertiary rocks to provide ample opportunity for the accumulation of petroleum. Reservoirs are thick and numerous in the Upper Cretaceous rocks of the Coastal Plain and seem to extend beneath the Shelf where marine source rocks may be expected. Rocks of Woodbine and Eagle Ford age appear to be a favorable reservoir-source rock combination whose thickness probably exceeds 2,000 feet offshore. The basal unconformity is important from the standpoint of petroleum accumulation, as in places it permits the basal Upper Cretaceous sandstones of Woodbine age to overlap the underlying, more marine Lower Cretaceous rocks.

Tertiary rocks along the Atlantic Coast exhibit very good reservoir and fair source rock characteristics. However, the Tertiary rocks are less promising for large accumulations of petroleum than the Jurassic and Cretaceous rocks. They probably are less than 4,000 feet thick in most of the area north of southern Florida and the Bahama Islands; they contain fresh-to-brackish artesian water in much of that area; they crop out in part along the Shelf and in other places give rise to submarine springs in sink holes. In addition, structural features are reflected less distinctly in the Tertiary rocks than in the older rocks, and unconformities and overlaps within the Tertiary rocks are less significant regionally than those in older rocks.

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The Continental Shelf offers more promise as a potential petroleum province than the Coastal Plain because it has a thicker sedimentary column with better source beds and trapping possibilities. The probabilities for discovery of large accumulations of petroleum in the Atlantic coastal region on a well-for-well basis seem to favor the Upper Jurassic and Lower Cretaceous rocks beneath the Continental Shelf.

Introduction

Area and purpose of report

The Atlantic Coastal Plain and Continental Shelf of North America are represented by a belt of Mesozoic and Cenozoic rocks, 150 to 300 miles wide and 2,400 miles long, extending from southern Florida to the Grand Banks of Newfoundland (fig. 1). This belt encompasses an area of

Figure 1 near here

about 400,000 to 450,000 square miles, more than three-fourths of which is covered to a depth of 100 fathoms by the Atlantic Ocean. The submerged part forms the Continental Shelf, which widens northward from 3 miles off Florida to about ~~300~~ 285 miles on the Grand Banks off Newfoundland. The area of the Continental Shelf, including the Gulf of Maine, approximates 350,000 square miles. The emergent part, the Coastal Plain, narrows northward from a 200-mile width in Georgia to the terminal point of Long Island. Beyond this point, remnants of the Coastal Plain are present in the form of the New England Islands and the Cape Cod Peninsula. The area of the Coastal Plain, including the eastern half of the Florida peninsula, approximates 100,000 square miles.

The volume of Mesozoic and Cenozoic rocks beneath the Atlantic Coastal Plain and Continental Shelf of North America exceeds 450,000 cubic miles, perhaps by a considerable amount (see Gilluly, 1964, p. 484, for estimates of volume between Nova Scotia and Virginia). More than one-half of this is seaward far enough to contain marine source rocks in sufficient proportion to attract exploration for oil. A larger fraction, perhaps three-quarters of the volume, may be of interest in exploration for gas.

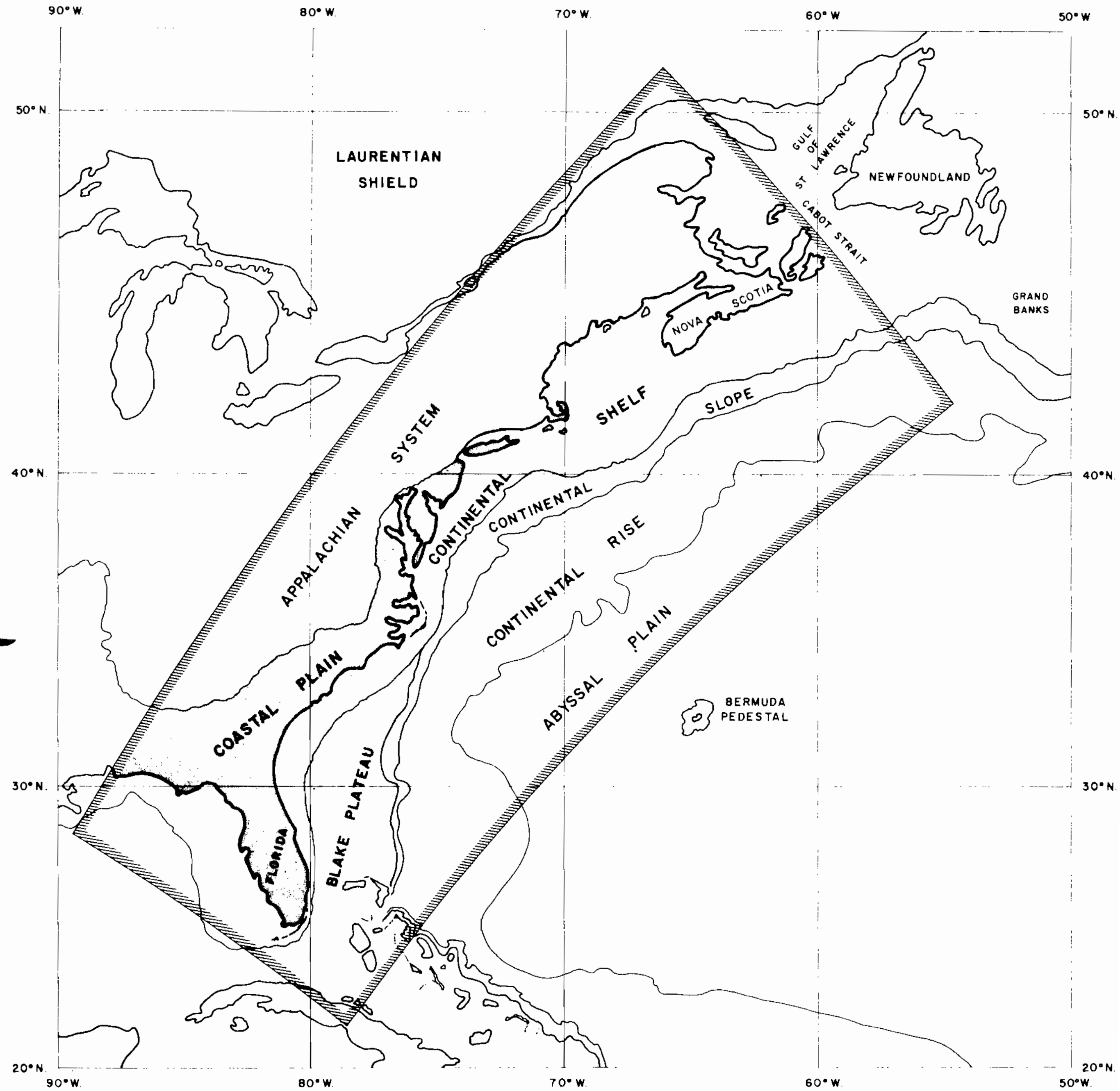

FIG. I PHYSIOGRAPHIC PROVINCE MAP OF EASTERN NORTH AMERICA SHOWING AREA DISCUSSED IN THIS REPORT

This report discusses the structure along the Atlantic Coast from southern Florida (Florida Keys) to Cabot Strait between Nova Scotia and Newfoundland (fig. 1), and the stratigraphy of the area between southern Florida and Cape Cod, Massachusetts. The Continental Shelf off Newfoundland is omitted because of lack of geological and geophysical information. Particular emphasis has been placed on the regional stratigraphic aspects of the subsurface rocks.

The purpose of this report is to establish a stratigraphic framework within this large sedimentary mass, to outline the structure of the continental margin, and to evaluate the petroleum possibilities of this relatively unexplored province to the extent possible at this time. It may serve also to aid or supplement the detailed oceanographic investigations being conducted jointly by the U. S. Geological Survey and the Woods Hole Oceanographic Institution along the Atlantic Continental Shelf (Emery and Schlee, 1963). It is by no means a summation of all geology and oceanography along the Atlantic Coast, but a selective review and synthesis of the regional aspects of the ancient rocks beneath the Coastal Plain and Continental Shelf, based on data available January 1, 1965.

Earlier reports and maps prepared by the Geological Survey have provided a broad review of the general characteristics, problems, and potential mineral resources of the continental shelves of the western hemisphere (Trumbull, Lyman, Pepper, and Thomasson, 1958); an estimate of the potential petroleum reserves of the Atlantic Coastal Plain and Continental Shelf based primarily on thickness of sediments (Johnson, Trumbull, and Eaton, 1959); a representation of the basement structure along the Atlantic Coast from Florida to the Gulf of Maine (Tectonic map of the United States, U. S. Geol. Survey, 1962) based on both geological and geophysical data published up to 1959; a report on correlations of subsurface Mesozoic and Cenozoic rocks along the Atlantic Coast (Maher, 1965); and a summary discussion of petroleum possibilities in relation to the stratigraphy (Maher, 1966). In addition, numerous publications have resulted from cooperative investigations with the Woods Hole Oceanographic Institution. These include a map showing the relation of land and submarine topography, Nova Scotia to Florida (Uchupi, 1965), a summary of the geology of the continental margin off eastern United States (Emery, 1965a), and many reports of lesser scope, most of which are mentioned herein where appropriate.

Sources and reliability of data

Many organizations provided well records and geological information for this report. Numerous oil companies made available samples, cores, electric logs, and data from deep oil tests. The Pure Oil Company permitted use of nonconfidential data from a reconnaissance report prepared by J. C. Maher and Irvin Bass in 1959. The Gulf Oil Corporation and Anchor Gas Company loaned samples and cores of their wells. State agencies and U. S. Geological Survey field offices engaged in ground-water investigations supplied a wealth of shallow subsurface data. The following state agencies are included in this group: Florida Geological Survey, R. O. Vernon, Director; Georgia Department of Mines, Mining, and Geology, the late Garland Peyton, Director; South Carolina Development Board, Henry Johnson, State Geologist; North Carolina Department of Conservation and Development, J. L. Stuckey, former State Geologist; Virginia Division of Mineral Resources, J. L. Calver, Director; Maryland Department of Geology, Mines, and Water Resources, K. N. Weaver, Director; and New Jersey Department of Conservation and Economic Development, Kemble Widmer, Director. The U. S. Geological Survey field offices include those at Tallahassee, Florida (C. S. Conover, District Engineer); Atlanta, Georgia (H. B. Counts, District Engineer); Columbia, South Carolina (G. E. Siple, District Geologist); Raleigh, North Carolina (G. G. Wyrick, District Geologist); Baltimore, Maryland (E. G. Otton, District Geologist); Trenton, New Jersey (Allen Sinnott, District Geologist); Mineola, New York (N. M. Perlmutter, Geologist-in-Charge); and Boston, Massachusetts (R. G. Peterson, District Geologist).

Some of the most useful publications on regional stratigraphy and structure of the Coastal Plain are those of Cooke and Munyan (1938), Applin and Applin (1944, 1947, 1965), Richards (1945, 1948, 1950), Southeastern Geological Society (1949), Spangler (1950), Spangler and Peterson (1950), Skeels (1950), Bonini (1957), Meyer (1957), Pooley (1960), Bonini and Woollard (1960), LeGrand (1961), and Murray (1961). Local reports that present important basic data in detail include those of Cederstrom (1943, 1945), Siple (1946), Swain (1947, 1951, and 1952), Anderson (1948), Applin (1951), Brown (1958), Puri and Vernon (1959), Herrick (1961), Herrick and Vorhis (1963), and Gill, Seaber, Vecchioli, and Anderson (1963); most of which are publications of state geological surveys. Other reports on the Coastal Plain geology are included in the appended list of references.

9-1267

Geophysical and oceanographic data on the Continental Shelf have been taken almost entirely from reports prepared by the Woods Hole Oceanographic Institution and the Lamont Geological Observatory and published in Bulletins of the Geological Society of America. These include articles by Ewing, Crary, and Rutherford (1937), Miller (1937), Ewing, Woollard, and Vine (1939, 1940), Ewing, Worzel, Steenland, and Press (1950), Oliver and Drake (1951), Officer and Ewing (1954), Drake, Worzel, and Beckmann (1954), Press and Beckmann (1954), Katz and Ewing (1956), Hersey, Bunce, Wyrick, and Dietz (1959), Drake, Ewing, and Sutton (1959), and Heezen, Tharp, and Ewing (1959). Bathymetry of the Shelf has been taken from the Tectonic map of the United States (U. S. Geological Survey, 1962) and navigation charts of the U. S. Navy Hydrographic Office (1951, 1962), the U. S. Coast and Geodetic Survey (1945, 1957, 1959, 1961, 1962), and the International Hydrographic Bureau (1958).

The amount and reliability of geologic and geophysical data on which this report is based differs greatly from one part of the region to another. The records of about 400 oil and deep water wells have been used in this report (pl. 1 and table 1), but more than half of these are for wells in Florida and Georgia. In addition, the geological records for these wells are more complete and accurate than those for wells in the northern part of the Coastal Plain. No deep tests have been drilled in offshore waters on the Continental Shelf, except in the Florida Keys area. In general, the geological data is much more reliable south of the Cape Fear arch than north of it.

9-1

Numerous seismic refraction profiles of the Continental Shelf have been published by different workers. Most are shown on plate 2, although space does not permit plotting of some short ones such as those off Sable Island (Berger, Blanchard, Keen, McAllister, and Tsong, 1965), Rhode Island (Birch and Dietz, 1962), Georgia (Antoine and Henry, 1965, fig. 1) and Florida (Rona and Clay, 1966). They are well distributed from northern Florida to Nova Scotia but little agreement exists on their stratigraphic interpretation, partly because of the pronounced effect of lateral facies changes on seismic velocity measurements. Some seismic profiles off southern Newfoundland (Press and Beckman, 1954; Bentley and Worzel (1956) have been published, but little or no information is available on the Grand Banks. The geophysical information available outlines the regional structure of the Shelf, but provides only speculative results for the stratigraphy at this time.

Acknowledgments

Numerous individuals have contributed to the completion of this report. E. R. Applin and P. L. Applin, who have pioneered in the Mesozoic stratigraphy of Florida, provided much basic data summarized in their numerous publications by the U. S. Geological Survey. They also made available considerable unpublished paleontologic data for wells in Alabama, Georgia, South Carolina, and North Carolina. E. R. Applin, who contributed the discussion of the paleontologic basis for age assignments in this report, was employed part time for a few months to supply additional paleontologic data on selected wells in Florida and the Anchor Gas ~~Company~~ No. 1 Dickinson well in New Jersey. In addition, both offered valued suggestions on many stratigraphic problems and reviewed cross sections KL, MN, and OP.

S. M. Herrick of the U. S. Geological Survey, Atlanta, Georgia, whose definitive paleontology has established the stratigraphic framework of subsurface rocks in Georgia, was most generous with published and unpublished data. His interested cooperation and thoughtful discussions of regional subsurface concepts were important to the completion of the cross sections. Cross sections IJ and KL were reviewed by Herrick.

P. M. Brown of the U. S. Geological Survey, Raleigh, North Carolina, provided data for several wells in North Carolina. He also reviewed cross section GH and offered valued criticisms.

R. E. Peck of the University of Missouri identified and gave an age opinion for a specimen of Charophyta from the Anchor Gas Company well in New Jersey. J. M. Schopf and R. H. Tschudy of the U. S. Geological Survey aided with opinions of the age of spores and pollen in the same well.

N. M. Perlmutter and Ruth Todd of the U. S. Geological Survey allowed the writer to read the manuscript of their report on the Monmouth group in the well at the Bellport Coast Guard Station, Long Island (well 6, pl. 1).

R. S. Stewart of the Anchor Gas Company, L. J. Franz and Roy A. Worrell of the Gulf Oil Corporation, W. D. Lynch and Marvin Horton of Chevron Oil Company, L. R. McFarland of Mobil Oil Company, K. N. Weaver of the Maryland Department of Geology, Mines and Water Resources, H. G. Richards of the Philadelphia Academy of Natural Sciences, W. E. Wilson of the North Carolina Geological Survey, J. L. Ruhle of the Virginia Geological Survey, and Clarence Babcock of the Florida Geological Survey provided cores, samples, and data for key wells. Special acknowledgment of assistance also is due to the following members of the U. S. Geological Survey: Seymour Subitzky, J. E. Johnston, W. N. Palmquist, N. D. Hoy, H. R. Bergquist, E. G. Otton, C. A. Richardson, C. A. Kaye, H. E. LeGrand, V. T. Stringfield, J. V. A. Trumbull, and J. F. Pepper.

Physiographic features

Provinces of western North Atlantic region

The physiographic provinces of the western North Atlantic region, as defined by Heezen, Tharp, and Ewing (1959) and outlined in figure 1, are the abyssal plain, the continental rise, the continental slope, the Continental Shelf, the Coastal Plain, and the Appalachian System. The abyssal plain is a part of the ocean-basin floor; the continental rise, slope, and Shelf make up the continental margin; and the Coastal Plain and Appalachian System are parts of the North American Continent.

The abyssal plain is the flat ocean bottom, with a slope of less than 1:1,000, that almost surrounds the Bermuda rise on which the Bermuda pedestal sets. Except in a small, isolated area near the Blake plateau and Bahama banks where calcareous sediments predominate, the surface is covered with quartz silt that Heezen, Tharp, and Ewing (1959, p. 58) suggest may come from the Cape Hatteras region or the Hudson Canyon (see fig. 2). Numerous seamounts are present in the northern part of the

Figure 2 near here

abyssal plain.

The continental rise begins rather abruptly at the edge of the abyssal plain and extends upward with slopes ranging from 1:100 to 1:700 to the continental slope. It is relatively wide, reaching several hundred miles in places. The depth of water on the continental rise ranges from 750 to 2,800 fathoms. It has low relief for the most part, but is represented by an outer ridge adjacent to the Blake plateau. A few submarine canyons extend across the continental rise (Ericson, Ewing, and Heezen, 1951, p. 964), and several seamounts are present off the New England coast.

The continental slope parallels the continental rise and Continental Shelf at depths ranging from 50 to 1,750 fathoms. The slope is relatively steep (3° - 6°) and narrow. The limits of the slope are marked at the base by a gradient in excess of 1:40 and at the top by the sharp break at the edge of the Shelf. Numerous submarine canyons traverse the continental slope.

The Continental Shelf extends from mean low-tide to the Shelf break, or beginning of the continental rise, which is somewhat less than 100 fathoms in depth at most places. It is a gently sloping surface with a gradient of less than 1:1,000 ranging in width from a few miles off Florida to more than 300 miles off Newfoundland. The relief is relatively low, although the surface is cut by numerous submarine canyons.

The Coastal Plain consists of land between the crystalline piedmont of the Appalachian System and mean low-tide from southern Florida to the tip of Long Island, a few small offshore islands, and the Cape Cod Peninsula. The Fall Line marks its inland limit along the Appalachian Mountains. Its maximum width is about 200 miles in Georgia and it narrows northward. The altitude ranges from sea level to about 800 feet, but is less than 300 feet in most parts.

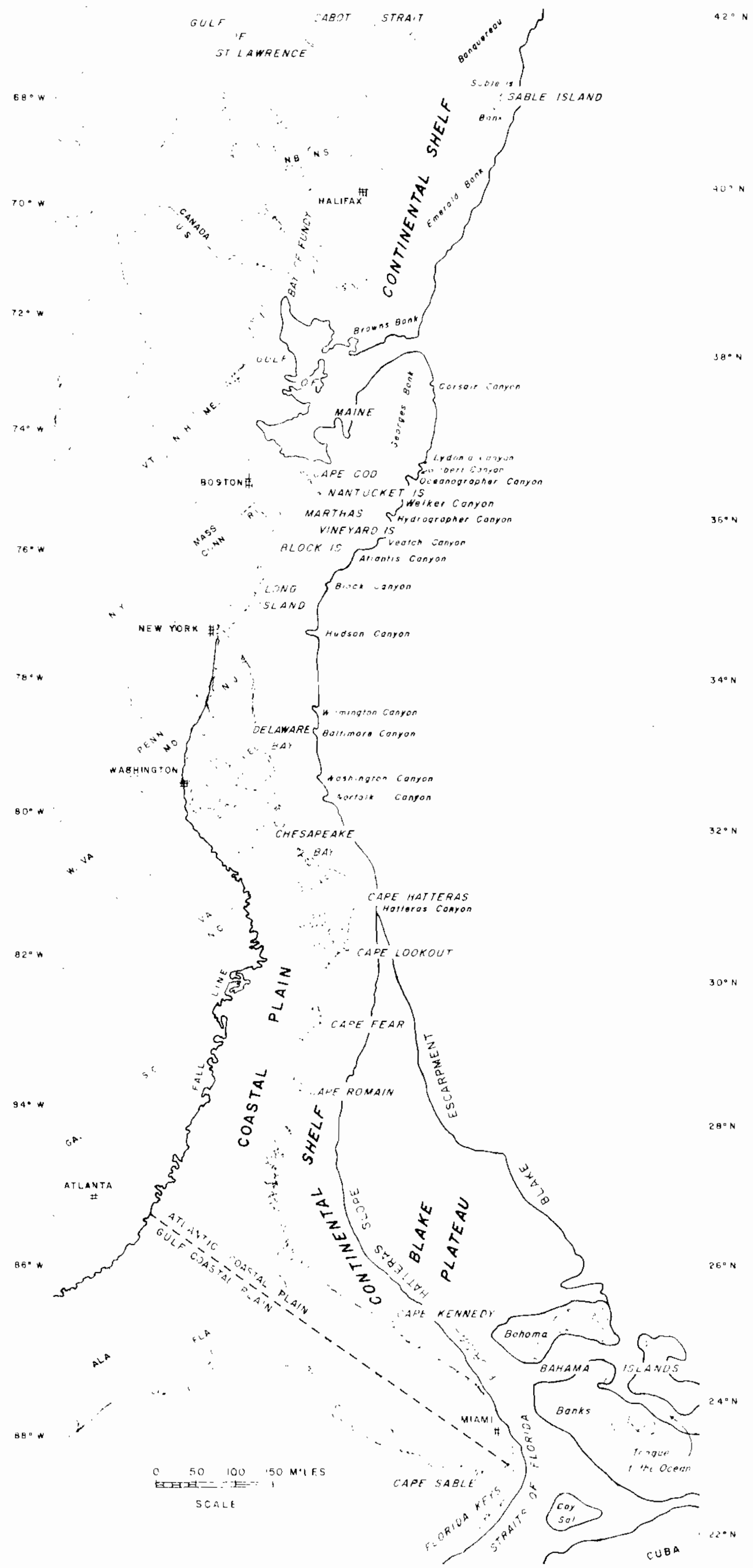

FIG 2 PRINCIPAL PHYSIOGRAPHIC FEATURES OF THE ATLANTIC COASTAL PLAIN AND CONTINENTAL SHELF

The Appalachian System is a highland of Paleozoic and older rocks stretching from the Canadian Maritime Provinces southwestward into Alabama. In the central and southern part, the System comprises three distinct, subparallel physiographic subdivisions: (1) the Piedmont province of moderate relief, with maximum altitudes of about 2,000 feet carved in crystalline rocks adjacent to the Coastal Plain, (2) the Blue Ridge and valley and ridge province of considerable relief with maximum altitudes of 5,000 to 6,000 feet and composed of faulted and folded sedimentary rocks, and (3) the Appalachian plateau province of highly dissected, flat-lying sedimentary rocks. These belts are less readily recognized in the northern section from New York to Newfoundland, where the topography is quite rugged.

The physiographic setting of the Coastal Plain and Continental Shelf is represented graphically in Plate 3. The gradient of the continental slope in this diagram is exaggerated considerably to emphasize the steeper slope of the Shelf break along the Blake Plateau in contrast to the gentler slope to the north. The extent and thickness of draping by younger sediments along this feature is not known.

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Coastal Plain

Area and configuration

The Atlantic Coastal Plain, as discussed in this report, consists of land between the crystalline piedmont of the Appalachian System and mean low tide of the Atlantic Ocean from the median line of the Florida peninsula to the terminal point of Long Island (Fig. 2). Farther northeastward, it is represented by Block Island, Marthas Vineyard, the Elizabeth Islands, Nantucket Island, and the Cape Cod Peninsula. This area exceeds 100,000 square miles.

The Coastal Plain stands low as compared to the area of the Appalachian tectonic system that borders it on the west, but it is not a featureless plain. Hills with 200 feet of relief are present in much of the inland area. Marine terraces are well-developed on its surface as a result of ancient changes in sea level. These terraces are traceable for long distances, and are characterized by features of ancient shorelines, such as wave-cut cliffs, beaches, spits, bars, and emerged deltas. The elevations of the terraces range from about 25 to 270 feet above present sea level--the higher are the older and less distinct.

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The sedimentary rocks that underlie the Atlantic Coastal Plain are soft and little resistant to erosion, but rest for the most part on a very resistant crystalline basement. Because of this difference in erosion resistance, the western boundary of the Coastal Plain sediments forms a topographic demarcation line. Falls and rapids are found in most of the seaward-flowing rivers at this line (the Fall Line) and because this line marks the upper limit of river navigation, many of the important eastern cities are located along it, such as Trenton, Philadelphia, Wilmington, Baltimore, Washington, Fredericksburg, Richmond, Columbia, and Augusta.

The Coastal Plain is deeply indented by branching bays or drowned river valleys and exhibits numerous large spits and bars from Cape Lookout, off North Carolina, northward to New York (pl. 3). South of Cape Lookout, drowned river valleys and barrier beaches are not as common and numerous small islands fringe the coast of the Carolinas and Georgia. Fenneman (1938, p. 13 and 38) termed the latter the <u>sea island section</u> and the former the <u>embayed section</u>.

Prominent shoreline features

Gulf of Maine

The Gulf of Maine, about 25,000 square miles in area, is the largest reentrant in the Atlantic Coast south of Cabot Strait (see fig. 2). It is almost enclosed by banks and shoals, beneath 3 to 50 fathoms of water, that swing southward in an arc linking Cape Cod and Nova Scotia (see Murray, 1947, for topography). One deep channel, 100 to 150 fathoms deep, cuts through the enclosing banks and shoals near Nova Scotia to connect with the deeper floor of the ocean (Torphy and Zeigler, 1957). The waters behind the banks are 50 to 190 fathoms deep in somewhat irregular fashion, suggestive of a former glacial lake-and-river drainage system behind a cuesta of Cretaceous and Tertiary rocks (Johnson, 1925, p. 267; Chadwick, 1949, p. 1967; Uchupi, 1966, p. 166-167). A long, constricted arm of the Gulf, the Bay of Fundy, through which exceptionally high tides pass, extends northeasterly between New Brunswick and Nova Scotia.

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Cape Cod Peninsula

Cape Cod Peninsula, a seaward projection of Massachusetts, is the most prominent emergent feature of the Atlantic shoreline (see fig. 2). Its geography and geology have been described by Davis (1896), Shaler (1898), and Woodworth (1934a, p. 237-249). The great size, strong relief, and bold projection of this Peninsula into the Atlantic Ocean are remarkable. In the shape of a man's arm bent at the elbow, the Peninsula projects about 40 miles eastward into the Ocean and then an equal distance northward into the Gulf of Maine. The age and development of this hook have been discussed recently by Zeigler, Tuttle, Tasha, and Giesel (1965). A long spur of sand trails southward from the elbow as Monomoy Island, a continuation of the long, straight, sandy shoreline along the entrance to the Gulf of Maine. The interior shore around Cape Cod Bay is low and swampy, whereas that facing the Ocean is more abrupt and indented farther by inlets. The topography of the Peninsula is dominated by morainal ridges and glacial hills with altitudes of 200 to 300 feet. Glacial drift masks the underlying geology, but Cretaceous and Tertiary rocks have been reported in wells near Provincetown at the tip of the Peninsula (Zeigler, Tuttle, Tasha, and Giese, 1960, p. 1397-1398; 1964, p. 708). Hoskins and Knott (1961) have interpreted continuous seismic profiles in the adjacent bay as showing marine Tertiary strata and erosional remnants of Cretaceous layers.

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Delaware Bay

Delaware Bay is the drowned lower valley of the Delaware River, which separates New Jersey from Delaware and Pennsylvania (see fig. 2). It is about 52 miles long and, at its broadest point, about 28 miles wide. The lower end is partially enclosed by the Cape May Peninsula of New Jersey and Cape Henlopen of Delaware. The main channel ranges in depth from 35 fathoms in the upper reaches to 150 fathoms near the mouth, but most of the Bay is less than 20 fathoms deep. Shoals ring the point of the Cape May Peninsula and parallel the channels upstream. The shoreline of the Bay is predominantly marshland.

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Chesapeake Bay

Chesapeake Bay, which divides northern Maryland and separates southern Maryland from Virginia (See Fig. 2), represents a drowned drainage system that includes the lower valleys of the Susquehanna, Potomac, Rappahannock, York, and James Rivers. It is over 160 miles long, more than 25 miles wide in its central part, and about 13 miles wide at its mouth between Cape Charles (Maryland) and Cape Henry (Virginia). The main channel ranges in depth from 20 to 82 fathoms and leaves the Bay close to Cape Henry on the south shore. A crescent-shaped series of shoals parallels the north shore around Cape Charles.

Cape Hatteras

Cape Hatteras projects about 32 miles eastward from the mainland of North Carolina. It marks the meeting point of two long offshore bars in the form of sweeping curves concave toward the sea. These offshore bars extend almost without interruption from a few miles south of Cape Henry at the mouth of Chesapeake Bay to Cape Lookout (See Fig. 2), a distance of about 120 miles. The bars are as much as 2 or 3 miles wide and 25 feet high at places, but are less than 1 mile wide and 10 feet high throughout most of their combined length. They enclose two sizeable, shallow bodies of water--Albemarle Sound at the north and Pamlico Sound at the south. These sounds include not only the lagoonal area behind the bars but also parts of the drowned valleys of the Chowan and Pamlico Rivers. The waters of the sounds are 25 fathoms deep in some places, particularly near the rivers, but mostly less than 15 fathoms in the lagoonal areas. A part of the large tract of marshland that separates the two drainage systems is known as East Dismal Swamp. The formation of the offshore bars at Cape Hatteras has been attributed by Davis (1924, p. 475-477) to reverse flow of great eddies along the shoreward margin of the northward-flowing Gulf current.

Cape Fear

Cape Fear marks the intersection of two long, open, and shallow bays midway between Cape Lookout, North Carolina, and Cape Romain, South Carolina (See Fig. 2). These bays, alined almost symmetrically on opposite sides of Cape Fear, are about 95 miles long and produce concavities of 20 to 25 miles in a coastline that is relatively free of barrier bars so common in the Cape Hatteras area. Although the Cape protrudes less than 20 miles beyond the general coastline of the region, its associated shoals jut out another 34 miles into the Atlantic Ocean. This Cape is related not only to marginal eddies in the Gulf Stream, but also to a structural arch prominent in the ancient rocks.

Cape Kennedy

Cape Kennedy, formerly Cape Canaveral, is not a very prominent shoreline feature, but it is the largest between Cape Romaine, South Carolina, and the tip of the Florida Peninsula (See Fig. 2). It projects about 14 miles seaward as the terminal point of a low, triangular mass of islands, bars, and coastal lagoons accreted to the mainland about midway along the eastern coast of Florida. The highest land surface in this complex is about 12 feet above sea level. The Cape is a point on the outer bar encompassing Merritts Island and the intervening subparallel coastal lagoons and rivers. The subparallelism of such waterways and the coastline is one of the outstanding features of the Florida coast. Shoals extend only a few miles seaward from Cape Kennedy; another shoal area, known as False Cape, lies about 8 miles to the north. The suggestion has been made by White (1958, p. 47) that Cape Kennedy is the result of deformation, and perhaps faulting, of the ancient rocks along a line from Indian Rocks on the west coast to Cape Kennedy.

Islands

At times during Pleistocene geologic history, the Coastal Plain has included a considerable part of the present-day Continental Shelf. The numerous islands along the Atlantic Coast were then the higher parts of the emerged Coastal Plain. The larger of these include Long Island, Block Island, Marthas Vineyard, the Elizabeth Islands, Nantucket Island, Sable Island, and the Florida Keys, most of which are shown on figure 2. The Bahama Islands also may have been a part of the continental land at some earlier period.

Long Island, Block Island, Marthas Vineyard, the Elizabeth Islands, and Nantucket Island, which make up the New England Islands, represent a former cuesta of Cretaceous and Tertiary rocks continuing mostly submerged from the New Jersey coast to the Cape Cod Peninsula. Thick Pleistocene glacial deposits mantle these islands, suggesting that the scarps of older rocks interfered with the southward advance of the ice masses and caused the local accumulation of glacial debris in moraines and outwash plains. A comprehensive report on these islands written by Woodworth and Wigglesworth (1934) has been drawn upon for the brief descriptions that follow.

Long Island

Long Island, 1,411 square miles in area, projects eastward from the East River of New York City to the longitude of Rhode Island. The island is about 120 miles long, less than 25 miles wide, and less than 200 feet in altitude except for a few ridges and hills reaching a maximum of 340 feet. The topography is essentially that of a glacial outwash plain sloping to the south, interrupted by two ridges of terminal moraines joined at the western end but extending separately along the remainder of the Island's length. One runs along the north shore and the other through the middle, diverging into the two eastern peninsulas about 14 miles apart. The southern shore of the Island is flat and protected by long barrier beaches most of its length. The eastern part of the northern shore is relatively straight and smooth due to active wave erosion, but the western part of the northern shore is deeply embayed. The steep-sided bays and inlets there are related historically to previously existing valleys eroded into the cliff face of Cretaceous beds dipping southward. Long Island Sound, a shallow arm of the sea less than 20 miles wide and 160 feet deep, intervenes between the northern shore and the New England coast. The geological formations underlying Long Island are Upper Cretaceous and Pleistocene in age. The geology is discussed in Veatch and others (1906), Fuller (1914), Suter, de Laguna, and Perlmutter (1949), de Laguna (1963), and Perlmutter and Geraghty (1963).

Block Island

Block Island, approximately 6 miles long and 4 miles wide, lies about 15 miles northeasterly from Long Island and about 10 miles off the Rhode Island coast. A small inlet separates the Island, highest at opposite ends, into north and south parts connected only by a strip of marshland and beach. Steep cliffs, 100 to 150 feet high, mark the southern coast. The Island is formed of thick glacial deposits thought to rest on and against a higher part of the former Cretaceous cuesta between New Jersey and Cape Cod (Fenneman, 1938, p. 14, 15). Tuttle, Allen, and Hahn (1961) have correlated a seismic velocity zone beneath the glacial deposits with the Magothy clay outcrops identified by Woodworth (1934b, p. 212).

Marthas Vineyard

Marthas Vineyard, about 100 square miles in area, is a triangular-shaped island, with its apex to the north, about 4 miles off the southwestern part of Cape Cod Peninsula. It is about 20 miles long and 10 miles wide, and rises to 308 feet above sea level near the southwestern corner. The northwestern side of the Island is lined with glacial hills and ridges, generally 100 to 200 feet higher than the central and southeastern lowlands. The lowlands slope gently southeastward, which results in numerous embayments closed by sand bars along the south shore. Although the hills and ridges are composed of coarse glacial debris and the lowlands of glacial outwash, Cretaceous and Tertiary rocks are at or near the surface in several places (Shaler, 1885, p. 325-328, pl. 20; Wigglesworth, 1934, p. 140-160). The subparallelism of the ridges to the coast resembles that of cuestas on a belted coastal plain. These rocks form the westernmost promontory of the Island known as Gays Head.

Elizabeth Islands

The Elizabeth Islands compose a short chain of a half-dozen islands, too small to show on figure 2, extending 16 miles southwesterly from Cape Cod Peninsula. They are alined subparallel to and 4 to 5 miles northwest of the ridges on Marthas Vineyard. These islands are covered with glacial materials for the most part, but one island, Nonamesset, next to the mainland, is reported to have exposures of Cretaceous lignite and Tertiary (Miocene) greensand on its south shore (Woodworth and Wigglesworth, 1934, p. 309-310). The alinement of the outcrops and topographic features on both Marthas Vineyard and the Elizabeth Islands add to the resemblance of submerged cuestas in the region.

Nantucket Island

Nantucket Island, 51 square miles in area, is the easternmost of the islands off New England. It is about 15 miles southeast of Marthas Vineyard and 10 to 20 miles south of Cape Cod Peninsula. The land surface is covered with glacial drift, and lies relatively low and flat. The few isolated hills range from 50 to 108 feet above sea level. The harbor on the north side of the Island is protected by a long barrier beach. Cretaceous and Tertiary rocks probably underlie the several hundred feet of glacial deposits penetrated by water wells on the Island. The geology of Nantucket Island has been described by Shaler (1899) and Woodworth (1934c, p. 93-116). Recently the pollen flora from a boring on the nearby Nantucket Shoals was described by Livingstone (1964), and by Groot and Groot (1964).

Sable Island

Sable Island, about one mile wide and 30 miles long, is a thin arc of sand bowed seaward about 100 miles off Nova Scotia at lat 44°N., long 60°W. It is the emergent part of a large shoal area called Sable Island Bank. The surface consists of stabilized sand dunes at the east end and along the north side. Sand flats surface the remainder of the Island. A narrow lake, a few miles long, splits the Island down the middle near its widest part. According to Willmore and Tolmie (1956, p. 13), the Island may be composed entirely of glacial deposits reworked in part by waves or it may have a glacially mantled scarp of Cretaceous or Tertiary rocks as a shallow substructure. Recent deep seismic observations by Berger, Blanchard, Keen, McAllister, and Tsong (1965, p. 959) suggest that the ridge in the basement which has been proposed to underlie the Shelf edge off Halifax (Officer and Ewing, 1954, fig. 2) continues northeastward beneath Sable Island, and that the thickness of sedimentary rocks under the Island approximates 14,750 feet.

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Florida Keys

The Florida Keys, well described by Cooke (1939, p. 68-70; 1945, p. 11, 256-265), constitute a low island arc curving along the Straits of Florida from Biscayne Bay near Miami 200 miles southwestward to the Dry Tortugas (see fig. 3). Between Biscayne Bay and Big Pine Key, the

Figure 3 near here

arc of islands consists of a coral reef interrupted by tidal channels, and the islands are elongate parallel to the Straits of Florida. Between Big Pine Key and Key West, the islands are composed of Miami oolite, such as crops out on the mainland, and the islands tend to be elongate to the northwest at right angles to the chain. The Marquesas, about 20 miles west of Key West, and the Dry Tortugas about 45 miles beyond the Marquesas, are coral sand banks in the form of atolls (Cooke, 1939, p. 70-72). About five miles seaward from the arc is a submerged living coral reef that parallels it throughout the entire length. The corals are growing upward through 10 fathoms of water. The largest island of the Florida Keys is Key Largo south of Biscayne Bay. It is 27 miles long and up to $3\frac{1}{2}$ miles wide. Most Keys are less than six miles long, a mile wide, and 10 feet in altitude. The Keys are separated from southern Florida by the Florida Bay, a shallow embayment mostly less than two fathoms deep, containing many mud banks and shoals. Mangrove swamps occupy much of the shallow water at the head of the Bay and behind the Keys.

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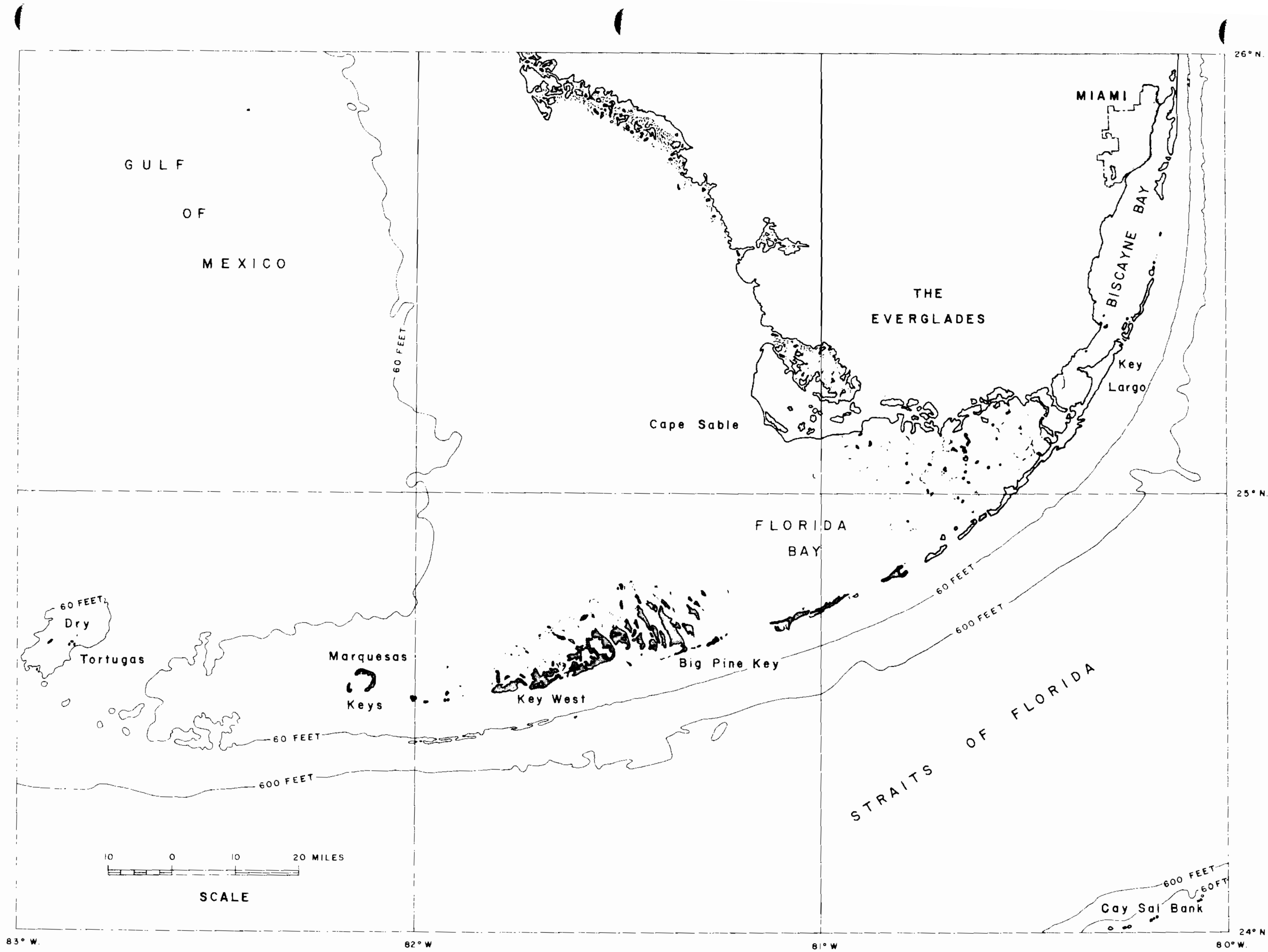

FIG. 3 PHYSIOGRAPHIC FEATURES OF FLORIDA KEYS REGION

Continental Shelf

Definition

Continental shelves, which exist along the margins of oceans throughout the world, extend from the mean low-water line to the abrupt change in slope known as the continental slope. This change is found at an average depth of 432 feet, or 72 fathoms. Commonly, the 100-fathom bathymetric contour shown on the hydrographic charts of the U. S. Navy Oceanographic Office (1411, 5617, and 6610) and the U. S. Coast and Geodetic Survey (1000, 1001, 1002, and 1003) is used to represent the seaward limit of the shelves around the United States. In this report, the 500-foot bathymetric contour from the Tectonic map of the United States (U. S. Geological Survey and American Association of Petroleum Geologists, 1962) is used. Because of the abrupt declivity at the edge of the Shelf, no appreciable difference in position or area of the Shelf is apparent on the small scale maps of this report.

General characteristics of continental shelves

The continental shelves of the World, which have an estimated area of 11 million square miles (Erwin Kosinna in Pratt, 1947, p. 658), and a volume of about 33 million cubic miles (Pratt, 1947, p. 658), are characterized by a relatively flat, almost level surface. The average inclination is only 12 feet per mile or 0°07'. The inclination is generally a little steeper inshore than in the outer half. The width ranges from less than a mile to many hundreds of miles. The most prominent features on the continental shelves are submarine canyons, which notch the shelf and cut deeply into the continental slope, submerged glacial moraines, troughs and basins near glaciated coasts, and coral reefs and banks. The seaward limit of the continental shelves, the continental slope, is the largest topographic feature on the earth's surface. Its area has been estimated to be 15 million square miles and its volume 40 to 50 million cubic miles (Pratt, 1947, p. 667). The slope meets the ocean floor at an average depth of 12,000 feet. The average inclination for the first 6,000 feet is 4°17', but in places the inclination exceeds 17°.

The topography of the continental shelves and the distribution of sediments on them are closely related to the alternate raising and lowering of sea level during different stages of Pleistocene time. The total fluctuation has been estimated at 250 to 500 feet both from positions of former strand lines and from theoretical calculations on the volume of ice during the ice age (Flint, 1957, p. 258-270). Dredging and coring operations have revealed highly irregular distributions of types and sizes of loose particles on the shelves. These distribution patterns seem to be controlled more by bottom topography, character of adjacent land, and type of remnant material on the bottom subject to reworking than by depth of water and distance from land. Bays and gulfs with strong currents, and open shelves have dominantly sand-size bottom sediments ranging from fine material near shore to coarse material seaward. Protected bays and gulfs without strong currents have dominantly muddy bottoms with the coarse material near shore and the fine material seaward. The seaward part of the open shelves generally has more coarse material and more bare rock bottom than the middle part, and in many places more than the landward part. Depressions in the shelves commonly contain finer-grained sediments. Shelves that have been subjected to glaciation have sediment distribution patterns less clearly related to recent depositional processes than those that have not.

A recent article by Emery (1965b) presents a summary of the characteristics of continental shelves and slopes, and enumerates the many questions remaining unanswered at the present stage of knowledge. Reference to this is suggested for more complete discussion.

9.1267

Area and configuration

The Atlantic Continental Shelf is a 2400-mile-long submerged platform, about 350,000 square miles in area, that widens from less than 3 miles off southern Florida to about 285 miles off Newfoundland (fig. 1). It extends subparallel to the shoreline and without interruption from the Straits of Florida to Cape Cod (fig. 2). At Cape Cod, the Shelf swings about 200 miles seaward to include Georges Bank; there it is interrupted by the deep outlet of the Gulf of Maine and turns back along the shoreline of the Gulf. It emerges from the Gulf at Browns Bank off Nova Scotia and parallels the open coast around Emerald Bank, Sable Island Bank, and Banquereau to Cabot Strait. Cabot Strait, the deep entrance to the Gulf of St. Lawrence, breaks the continuity of the Shelf, but it resumes around Newfoundland to the termination of the Grand Banks. This report discusses the part of the Atlantic Continental Shelf south of Cabot Strait, including the Gulf of Maine.

Along the entire Atlantic Coast, the 50-fathom (300-foot) bathymetric contour, as shown on U. S. Coast and Geodetic Survey Charts 1000, 1001, and 1002, closely parallels the Shelf edge at a distance of only a few miles. Farther inshore, the bottom contours are more widely spaced and show more parallelism to coastal shapes than to the Shelf edge. This 50-fathom contour may approximate the limit of subaerial erosion at the close of Pleistocene (Wisconsin) time. Earlier Pleistocene shorelines may have ranged from this level to the Shelf break.

The 5,000-foot bathymetric contour, as shown on the Tectonic map of the United States (U. S. Geol. Survey and Am. Assoc. Petroleum Geologists, 1962), parallels the Shelf edge at a seaward distance of 10 to 20 miles from Nova Scotia to as far south as Cape Lookout (pl. 1 and fig. 2), where instead of following the coastline and Shelf, it continues almost due south along a steep declivity outside the Bahama Banks. The 150-to-200 mile wide flat area between this steep declivity, the Shelf edge, and the Bahama Banks is termed the Blake Plateau. The gentle slope at the Shelf edge is sometimes referred to as the Florida-Hatteras slope to distinguish it from the true continental slope outside the Blake Plateau.

Blake Plateau

The Blake Plateau occupies an area of about 70,000 square miles between the 500 and 5,000-foot bottom contours from Cape Lookout to Little Bahama Bank, the northernmost bank of the Bahamas (pl. 1 and fig. 2). Although the 500-foot bottom contour closes around Little Bahama Bank and does not cross the Straits of Florida, the slightly deeper contours trend across this channel somewhat in line with the projection of Cape Kennedy on the mainland. A large reentrant at lat 27°N., and a seaward projection at lat 30°N. are the largest irregularities along the steep edge. On the basis of depth of water, the Blake Plateau would be classified as a part of the continental slope, but topographically and geologically it seems to resemble the Shelf. It has a gentle slope of about 1.5° with only minor irregularities and little, if any, cover of Recent sediments. Small hills and small, elongate depressions are present on the surface in places. Rocks of Upper Cretaceous to Recent age have been recovered from the steep edge of the Plateau (Ericson, Ewing, and Heezen, 1952, p. 504-506). This steep edge is known as the Blake escarpment. Early oceanographic studies of the region were reported by Bartlett (1883) and Agassiz (1888, p. 95-97). Details of some recent investigations are available in reports by Stetson, Squires, and Pratt (1962), Pratt (1963, 1966), Pratt and Heezen (1964), and Uchupi and Tagg (1966).

Bahama Banks

The Bahama Banks comprise a shallow carbonate platform elongated parallel to the coast between the Straits of Florida, Bahama Channel, and the much deeper part of the continental rise (fig. 4). This

Figure 4 near here

platform, about 50 miles offshore, extends with some interruptions as far southeast as Haiti and includes about 50,000 square miles of banks, shoals, rocks, cays, and islands. The northernmost banks, about 200 miles wide, are the most extensive. They are outlined on figure 2 by lines coinciding with the 500-foot bottom contours. The edges of the banks, particularly the oceanward edges, have steep slopes averaging 10° to 20°; some are nearly vertical. Most banks are covered by less than 10 fathoms of water, and parts are emergent as the Bahama Islands. Detailed studies of present-day sedimentation around the islands are discussed or referred to in Cloud (1962). Great submarine valleys, such as the Tongue of the Ocean (fig. 2) separate some of the banks. These valleys are steep-sided, with flat bottoms sloping gently oceanward. Several are 5,000 to 6,000 feet deep. The origin of these valleys has been attributed to coral reef growth on submarine volcanoes (Schuchert, 1935, p. 26, 27, 531) or on drowned pre-Cretaceous topography (Hess, 1933, p. 27-54; 1960, p. 160-161; Newell, 1955, p. 314), to turbidity currents (Ericson, Ewing, and Heezen, 1952, p. 506), and to grabenlike downfaulting (Talwani, Worzel, and Ewing, 1960, p. 156-160). No general agreement on the origin exists at this time. Comprehensive reports on the stratigraphy and structure of the Bahama Banks include those by Field (1930) and Lee (1951).

Cay Sal Bank

Cay Sal is a relatively small, somewhat rectilinear bank located at approximately lat 24°N., and long 80°W., midway between the Florida Keys, Cuba, and the Bahama Banks (fig. 2). Numerous small islands, cays, rocks, and shoals outline its periphery, but most of the Bank is covered by 3 to 10 fathoms of water. The edges slope abruptly to depths of 150 to 400 fathoms. An oil test was drilled on this Bank by the Bahama California Oil Company and the Bahama Gulf Oil Company in 1958 and 1959, but no information has been released.

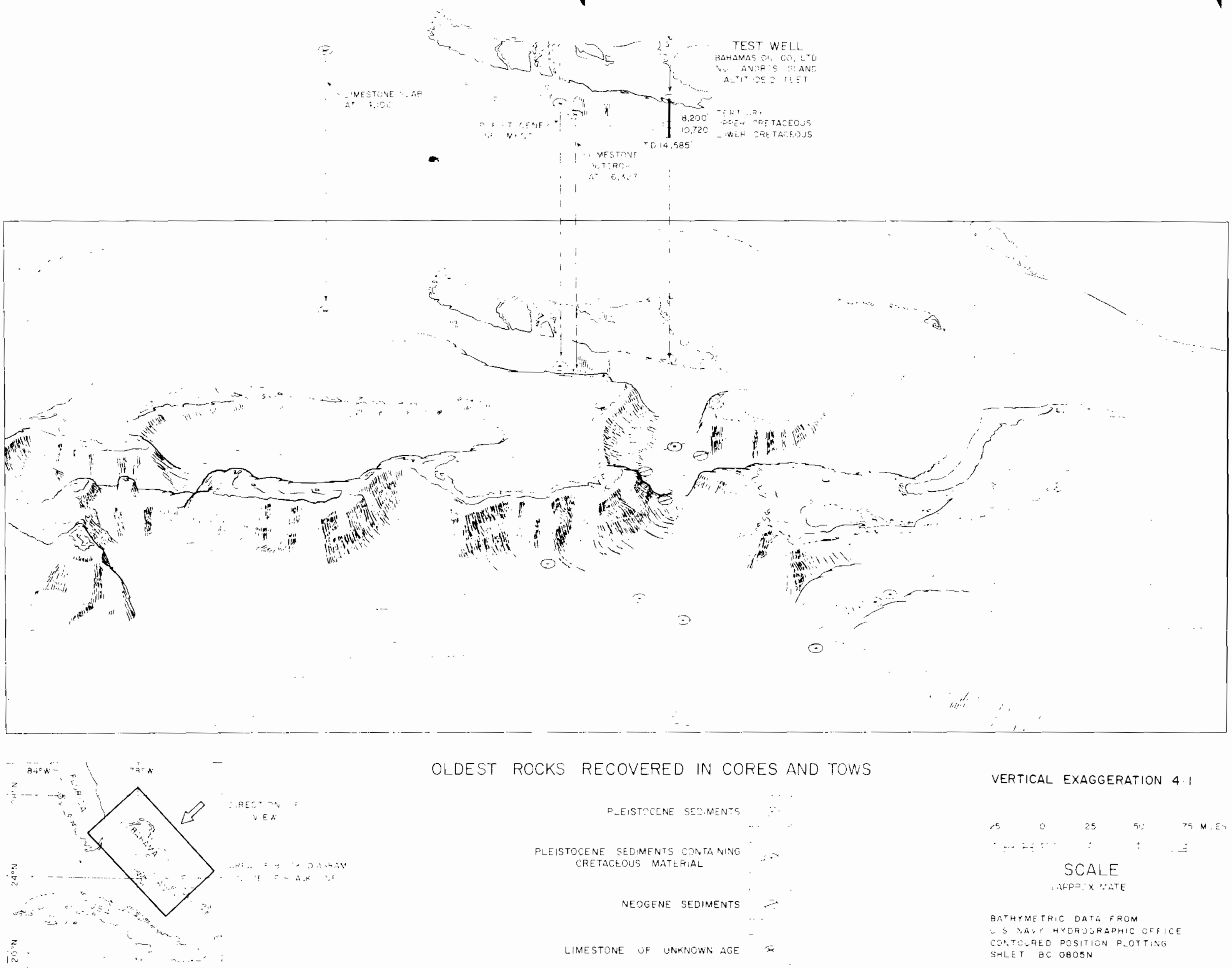

FIG. 4 PHYSIOGRAPHIC DIAGRAM OF BAHAMA BANKS SHOWING RELATION OF GEOLOGIC DATA TO BATHYMETRY

North Atlantic banks

A series of banks on the outer Continental Shelf parallel the North Atlantic coast from a point several hundred miles east of Newfoundland to the vicinity of Cape Cod. The Grand Banks off Newfoundland (fig. 1) are the most extensive. They consist of a large number of irregular banks that average 30 fathoms in depth. The deep channel of Cabot Strait, which leads into the Gulf of St. Lawrence, separates the Grand Banks from those along the Nova Scotian coast.

South of Cabot Strait, closely spaced banks, less than 60 fathoms deep and between 10 and 25 miles wide, dominate the outer Continental Shelf. Banquereau, which lies under 20 to 40 fathoms of water, is the northernmost of these. Next is Sable Island Bank, in less than 20 fathoms of water around Sable Island, and then Emerald Bank and several other small banks at depths of 40 to 50 fathoms off Halifax. Browns Bank lies off the southern tip of Nova Scotia parallel to the entrance to the Gulf of Maine in 20 to 60 fathoms of water. Georges Bank, a very large bank connecting to the shoals off Cape Cod, lies across the mouth of the Gulf of Maine at depths of 1 to 50 fathoms, and exhibits shoals in the shape of subparallel ridges pointing into the Gulf. These subparallel ridges may be the result of glaciation. Cretaceous and Tertiary fossils and glacial materials have been dredged from Georges Bank and Banquereau (see Submarine outcrops and bottom deposits). Johnson (1925, p. 267) considered both Georges and Browns Banks as parts of a drowned cuesta of Cretaceous and Tertiary strata, and Shepard (1934, p. 281-302) emphasized the effect of glaciation on and behind the cuesta. Recent seismic profiles over Georges Bank (Emery and Uchupi, 1965) and along the Northeast Channel (Uchupi, 1966, p. 166-167) between Georges and Browns Banks tend to confirm these earlier views.

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Submarine canyons

Numerous submarine canyons have been discovered along Georges Bank and southward to Cape Hatteras (U. S. Coast and Geodetic Survey Nautical Charts 1107, 1108, and 1109). These have been described and discussed in detail by Bucher (1940), Stetson (1936), Shepard (1933, 1934a, 1934b, 1948, 1951a, 1951b, 1963, p. 327-329), Veatch and Smith (1939, p. 1-48), Daly (1936), Ewing, Luskin, Roberts, and Hirshman (1960), Johnson (1938, 1939), ~~and~~ Kuenen (1950, p. 485-493) and Roberson (1964). Fifteen principal canyons are shown on figure 2. From north to south, these are Corsair, Lydonia, Gilbert, Oceanographer, Welker, and Hydrographer Canyons off Georges Bank; Veatch, Atlantis, Block, and Hudson Canyons off Cape Cod and Long Island; Wilmington, Baltimore, Washington, and Norfolk Canyons off the Delaware, Maryland, and Virginia coasts, and Hatteras Canyon off Cape Hatteras, North Carolina. Most head in broad notches in the edge of the Shelf at depths of 50 to 100 fathoms, but the Hatteras Canyon appears to start considerably deeper in the vicinity of the 200-fathom depth. The canyons that notch the Shelf have steep, winding, v-shaped gorges with many tributaries, in consolidated and semi-consolidated rocks. They range from about a mile to more than 10 miles in width, and extend far down the continental slope to depths of 1,000 fathoms or more.

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Only the Hudson Canyon has a channel that crosses the Shelf to connect with a present-day river mouth, although shallow bottom contours indicate drainage patterns above 50 fathoms that may have once connected to Corsair, Oceanographer, Hydrographer, Block, Baltimore, and Norfolk Canyons. This suggests that many channels drained across the Shelf when it was exposed during the advances of Pleistocene glaciers, and that these channels were modified or eliminated by encroaching seas during the retreats of the glaciers (Veatch and Smith, 1939, p. 44-48). Many large gullys, some of which appear dendritic, cut into the slope below the Shelf in this area. These bear no apparent relation to the principal canyons and may have a different origin.

The Hudson Canyon (Veatch and Smith, 1939, p. 14) is the longest and deepest of the North Atlantic coast canyons (fig. 5). The channel of

Figure 5 near here

the Hudson River is entrenched 8 to 25 fathoms, or about 50 to 150 feet, into the Shelf from the mouth of the river to the 60-fathom depth marking the beginning of the gorge. Beyond this, the Canyon walls reach a maximum height of 4,000 feet as they descend the slope and rise to a terminal depth of approximately 2,650 fathoms or 15,900 feet (Northrop, 1953, p. 223). The lower part of the 180-mile-long Canyon is a relatively shallow trench across a large alluvial fan on the continental rise. Miocene clays have been found on the sides of the gorge; coarse sand, gravel, shells, and clay cobbles were cored in the Canyon at a depth of 12,000 feet; and cleanly-washed sand has been sampled in the outer trench and alluvial fan. The results of acoustic probes and cores of the Canyon walls (Ewing, Luskin, Roberts, and Hirshman, 1960, p. 2849-2855) suggest inclined erosional surfaces between beds adjacent to the Canyon edge at depths of 60 and 80-90 fathoms. These are thought to correlate with wave erosion of the Shelf during different Pleistocene times, as suggested by Veatch and Smith (1939, p. 44-48).

The origin of submarine canyons has been a subject of speculation, discussion, and investigation for more than fifty years. The theories that have been advanced and restated at different times include subaerial erosion (Veatch and Smith, 1939, p. 48; DuToit, 1940; Shepard, 1948, 1963, p. 335-347; Umbgrove, 1947, p. 97-143; and Emery, 1950), turbidity currents (Daly, 1936; Kuenen, 1953, p. 496-526), diastrophic movements (Wegener, 1924, p. 177), artesian springs (Johnson, 1939), tsunamis (Bucher, 1940), hydraulic and tidal currents (Davis, 1934), and landslides and mudslides. Shepard (1963, p. 337) points out that all but two of these have been generally discarded in recent years. The surviving theories are turbidity currents, and subaerial erosion with the drowning and maintenance of the canyons by turbidity currents, submarine slides, and sand flows. The first considers the canyons to have been cut by turbidity currents during low sea-level stages of the Pleistocene. The second assumes the canyons to have been cut by rivers prior to the Pleistocene and modified subsequently by submarine phenomena including turbidity currents.

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Origin of shelves

The origin of continental shelves is directly related to that of the continental slopes. Numerous theories of origin have been advanced over the years, but none has been completely acceptable for all parts of the earth. These theories have been reviewed and discussed in detail by Kuenen (1950, p. 157-163) and Shepard (1963, p. 300-310).

The oldest theory, which prevailed before very much geophysical and geological data could be obtained from beneath the seas, postulated that the slope is the front of a huge pile of sediment eroded from the continent, the inner shelves are wave-cut terraces, and the outer shelves are wave-built terraces. This theory has been generally discredited by then-unknown facts such as the absence of sedimentation on the outer shelf in many regions, the unpredictable grain-size distribution of sediments on the shelf, the presence of large areas of bare bed rock on both the shelf and slope, the irregular topography of the outer shelf, the lack of correlation between the size of waves and depths of the outer shelf, and the relatively high inclination of the slope surface.

Another concept, not in current favor, suggests that the slopes are downwarped remnants of Miocene peneplains (Veatch and Smith, 1939, p. 35). DuToit (1940, p. 398-403) and Umbgrove (1946, p. 251; 1947, p. 97-143) offered somewhat similar views involving arching along the coast, with different mechanics. The presence of exposed bedrock on the slope where sediments would be expected, the lack of observed downward bending of strata in the slope and outer shelf, and seismic evidence of a rise in the basement along the outer shelf tend to discredit most of this theory.

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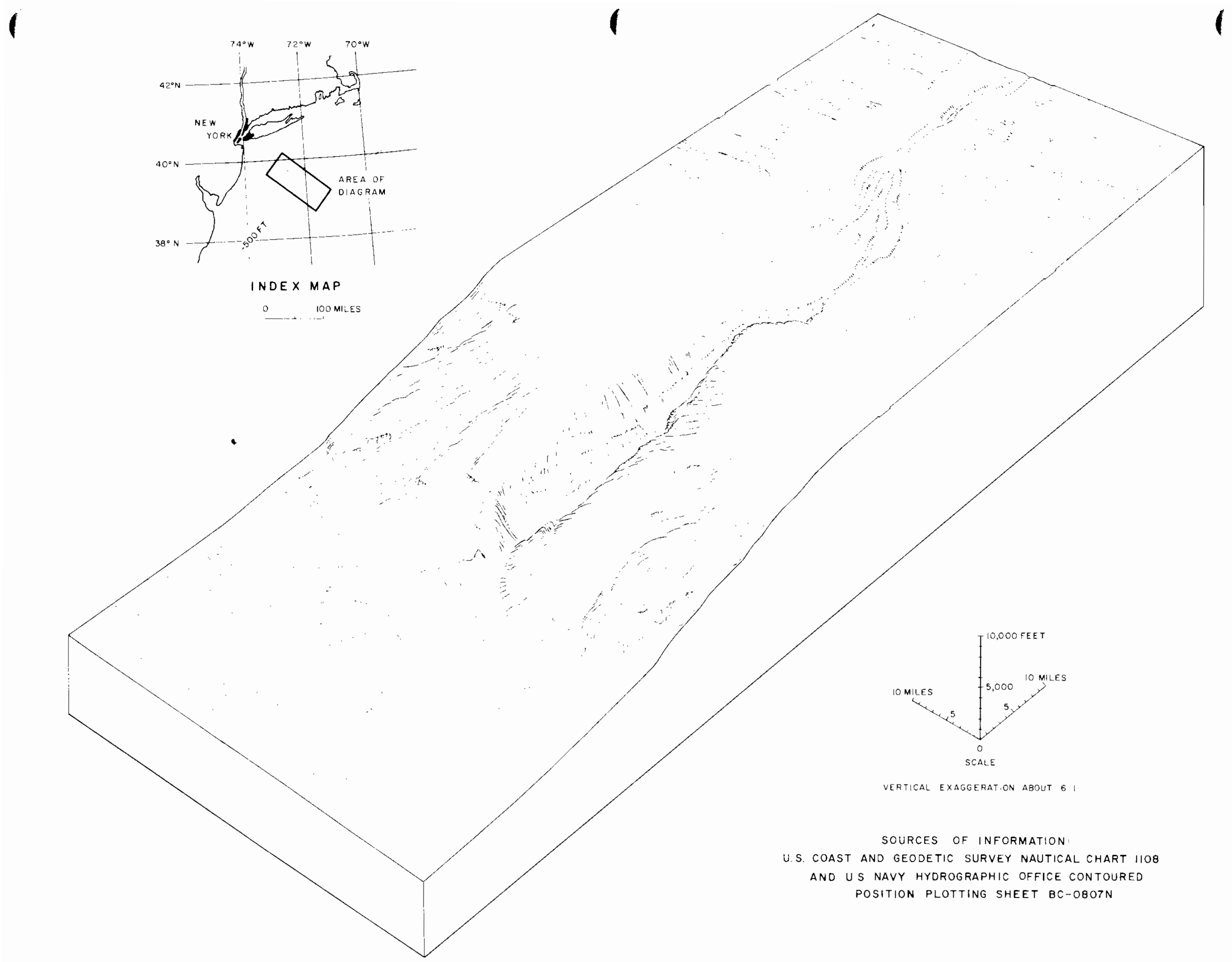

FIG. 5 PHYSIOGRAPHIC DIAGRAM OF HUDSON CANYON
ACROSS THE ATLANTIC CONTINTENTAL SHELF

The most acceptable theories regarding the origin of the shelf and slope now center around diastrophic movements near the contact of the continental and oceanic crust, according to Shepard (1963, p. 310) who cites as supporting evidence the general straightness of the slopes, the angular changes in trend, the excessive steepness, the association with earthquake belts and deep trenches in the Pacific, and the outcrop of rocks along the slopes at different places.

Numerous writers have invoked faulting in their explanations of the continental shelf and slope, but few have agreed on the mechanics. Shepard (1963, p. 303-306) and Heezen, Tharp, and Ewing (1959, p. 51) have favored normal faulting. The slope appears to fit the juncture between the heavy oceanic crust and the lighter continental crust, where isostatic adjustments might be expected to compensate for erosion lightening the continental mass and deposition weighting the ocean floor. Such adjustments could produce long normal-fault scarps, possibly a band of step faults, dipping away from the continent. Some warping of the continental margin also could accompany this. However, most continental slopes are not active fault zones now and their inclination is much less than most fault scarps on land. Heezen (1962, p. 242) believes that the continental slope seems to be a relic related to normal faulting which occurred at some earlier time, and that the upper part of the slope has been modified since by depositional and erosional processes.

Emery (1950) suggested that high-angle thrust faults extend beneath the continental mass from the margins. This idea is supported by the distribution of earthquake epicenters in an ever-deepening pattern beneath the continents. Emery thought it possible that these thrust faults elevated the continental margins sufficiently to permit subaerial erosion of the canyons now present on the shelf and slope.

Drake, Ewing, and Sutton (1959, p. 176-185, 191-194) have compared the Continental Shelf and slope of eastern North America to the miogeosyncline and eugeosyncline of the Appalachian system and have discussed the mechanics of thrusting and folding necessary to add the contained sediments to the land mass of the continent. Dietz (1963a, p. 1-21; 1963b, p. 314-333) has proposed along similar lines that the slopes have been constructed by the compressional collapse and folding of the continental rise sedimentary prism against the continental block -- the flanks of the resulting eugeosynclinal orogen becoming the continental slope. However, he also suggests that continental drift and rifting have given rise to some rift scarps that have been modified as continental slopes.

Van Bemmelen (1956, fig. 3, p. 139) depicted a graben structure along the Atlantic Coast of North America. Later, Engelen (1963, p. 65-72) expanded on this concept and showed diagrams of the development of the graben structure based on his interpretation of geophysical profiles published by Heezen, Tharp, and Ewing (1959, pl. 26). According to his hypothesis, block faulting started in Early Cretaceous time in the northern part and progressed slowly southward through Tertiary time.

The results of the JOIDES test-drilling program off northeastern Florida in 1965 suggest some of the difficulties in making world-wide generalizations about the origin of continental shelves and slopes. North of Cape Hatteras, the Continental Shelf and slope are adjacent, and together mark the continental margin. South of Cape Hatteras, the Shelf and slope are discordant -- the Shelf is widely separated from the slope by the Blake Plateau. There the continental margin seems to lie not along the Shelf edge, but along the Blake Plateau. The JOIDES test holes and sparker profile off Jacksonville, discussed later under "Stratigraphy", reveal that the Shelf of the present time had a depositional origin probably related to the velocity axis of the Gulf Stream (see Shepard, 1959, p. 116-117). The Shelf area appears to have been prograded seaward rather continuously since early Tertiary time for a distance of 9.3 miles at the JOIDES sites (JOIDES, 1965, p. 715). The JOIDES investigation did not extend to the Blake escarpment nor did it provide any data on the Cretaceous strata. Therefore the nature and origin of continental margins is still a matter of speculation even in this area and it seems obvious that no one explanation will fit all shelves and slopes of the world.

Structure

Regional structural pattern

The Appalachian Mountain System forms the structural backbone of eastern North America, extending from Newfoundland southwestward to central Alabama. See King (1959, p. 41-66; 1964, p. 5-31) for a comprehensive analysis of this System. In the United States, it consists mainly of a narrow anticlinorium of early Paleozoic and Precambrian rocks at the west known as the Blue Ridge Province, and a long, broad belt of intensely deformed and intruded Paleozoic rocks at the east termed the Crystalline Appalachians (see pl. 4). The Crystalline Appalachians, which form the New England Uplands to the north and the piedmont plateau to the south, exhibit the most intense deformation. These metamorphosed Paleozoic rocks crop out in a continuous belt as much as 130 miles wide from Alabama to Canada, except for a 50-mile interval in New Jersey occupied by downfaulted Triassic rocks. Several downfaulted basins of Triassic continental clastic rocks are present also in the piedmont plateau and in the basement beneath the Coastal Plain deposits.

The Mesozoic and Cenozoic sedimentary rocks of the Coastal Plain overlie in part and wedge out against the eastern flank of the Appalachian positive structural element raised by late Paleozoic orogeny. As a result, the regional structure of the Coastal Plain deposits reflects the major structural anomalies and trends of the Precambrian and Paleozoic rocks. The Appalachian's salient in the Carolinas corresponds with the Cape Fear arch outlined by Tertiary outcrops; the Appalachian's recesses in Georgia, New Jersey, and Maryland are matched by large embayments in the Coastal Plain deposits; and in Florida the Peninsular arch formed in the basement rocks in ~~late~~ Paleozoic time is closely related to the offsetting Ocala uplift of Tertiary ~~Eocene~~ age.

The regional structure of the pre-Cretaceous basement rocks as known from outcrops and wells, and inferred from geophysical surveys, is depicted by contours on plate 4, adapted from the Tectonic map of the United States (U. S. Geol. Survey and Am. Assoc. Petroleum Geologists, 1962). The basement rocks include not only the igneous and metamorphic rocks of Precambrian and Paleozoic age, and volcanic and sedimentary rocks of Triassic(?) age, but also unmetamorphosed sedimentary rocks of Paleozoic age beneath the Florida peninsula.

The structural contours on the basement rocks beneath the Coastal Plain parallel the Appalachian Mountain System except at the boundary between North and South Carolina, where they bulge seaward on the Cape Fear arch, and beneath the Florida peninsula, where the deeper contours are deflected around the southeasterly elongated Peninsular arch. The basement surface dips seaward at rates ranging from ten feet a mile inland to as much as 120 feet a mile near the ocean. It reaches the coast at depths in excess of 12,500 feet in southern Florida; 5,000 feet in southeastern Georgia; 1,500 feet in the Carolinas; 9,500 feet in southeastern New Jersey; and 2,000 feet along the south shore of Long Island. A decided steepening of the slope is apparent below a depth of 3,000 feet in most of the area. Prouty (1946, p. 1918) first recognized this steepening in wells in North Carolina.

The basement configuration beneath southernmost Florida and the Keys is not known from wells or seismic surveys. Lower Cretaceous beds exhibit a broad reversal of southerly dip north of Miami and a gentle rise of about 1,500 feet to the Florida Keys (Applin and Applin, 1965, figs. 50, 51 and 52), and may reflect to some extent the configuration of the basement rocks. However, the southward thickening of the intervening wedge of Upper Jurassic or Lower Cretaceous (Neocomian) beds cannot be judged from present data, so the relation of the basement configuration to the structure of the Lower Cretaceous beds is a matter of speculation.

Seismic data (see pl. 2) have been sufficient to permit contouring of the basement surface beneath the continental margin in much of the offshore area north of Cape Hatteras. There the basement surface slopes abruptly downward offshore and descends into what Kay (1951, p. 82) has termed the Atlantic geosyncline. This geosyncline, a paraliageosyncline of Mesozoic rocks along the Atlantic Coast according to Kay (1951, p. 82), consists of parallel troughs separated by a ridge along the edge of the Continental Shelf (see pl. 4). Ewing, Worzel, Steenland, and Press (1946, 1950) first concluded from seismic surveys between Cape Henry, Virginia, and Cape Cod, Massachusetts, that the basement surface does not slope uninterruptedly across the continental margin, but upon reaching a depth of about 16,000 feet, 40 miles off Delaware Bay, rises to a depth of about 10,000 feet at the edge of the Continental Shelf (see cross section EFF', pl. 5). Similar findings off Nova Scotia were reported by Officer and Ewing (1954, fig. 2). Drake, Ewing, and Sutton (1959, fig. 29) presented a thickness map of total sedimentary rocks on the basement between Cape Hatteras and Halifax, Nova Scotia, in which a second parallel trough containing as much as 20,000 feet of sedimentary rocks was depicted beneath the continental slope. They compared the two troughs separated by a basement ridge to the early Paleozoic troughs of the Appalachians as restored by Kay (1951, pl. 9) and suggested that the inner trough may represent the miogeosyncline; the basement ridge, the geanticlinal barrier; and the outer trough, the eugeosyncline (see cross section CDD' and EFF', pl. 5). This suggestion has met with considerable approval.

South of Cape Hatteras, the basement surface has been contoured to the edge of the Continental Shelf, but seismic data are too scattered to extend these contours across the Blake Plateau and Bahama Islands to the continental slope. Seismic records have been found to be generally poor in the thick carbonate rocks south of Georgia. The contours on the Shelf parallel the coast for the most part, but bulge seaward off Cape Fear and landward in the Southeast and Southwest Georgia embayments. Data are not sufficient to contour the basement surface beneath southernmost Florida at this time.

The effect of the Cape Fear arch upon the regional structure between Jacksonville, Florida, and Cape Hatteras, North Carolina, is illustrated by plate 6. Offshore seismic cross section AA' adapted from Hersey, Bunce, Wyrick, and Dietz (1959, fig. 3) is compared to stratigraphic cross section AB of this report. From this comparison, it appears that the seismic velocities approximating six kilometers a second represent the pre-Mesozoic basement rocks and that these rocks are about 12,000 feet deep offshore north of Cape Hatteras, about 2,500 feet deep off Cape Fear, and more than 20,000 feet deep offshore south of Jacksonville. Hersey, Bunce, Wyrick, and Dietz (1959, p. 448) have tentatively correlated the 5.16-5.35 km./sec. layer at the south and the 4.30 km./sec. layer at the north with the top of the Lower Cretaceous. The 3.27-3.88 km./sec. layer at the north is correlated by them with the top of the Black Creek Formation (top of rocks of Taylor age), but is not correlated at the south. The Black Creek correlation at the north seems uncertain, as the top of rocks of Taylor age is not a distinct lithologic horizon in the nearest wells (pl. 11). The top of rocks of Austin age and that of rocks of Woodbine age would seem to offer better possibilities for seismic velocity change. The 2.26-2.89 km./sec. layer they consider to be near the top of the Upper Cretaceous rocks offshore between Jacksonville and Cape Hatteras. This, too, seems very uncertain as comparison to the stratigraphic cross section suggests the 2.26-2.89 km./sec. layer is too shallow to be Upper Cretaceous, and may be closer to the top of the Eocene rocks. This velocity layer is less than 1,500 feet deep at Cape Hatteras; the top of the Upper Cretaceous rocks in the Cape Hatteras well (well NC-14) has been placed at 3,033 feet and the top of the Eocene (Castle Hayne Limestone) rocks at 1,738 feet in this study. The irregular and rising velocity layers south of Cape Fear suggest that they result from a general facies change to carbonate in that direction, and cannot be relied upon for stratigraphic equivalence.

Regional Bouguer gravity anomalies

Early gravity investigations along the Atlantic seaboard were concerned primarily with relating gravity to surface geology and to seismic and magnetic data (Swick, 1937; Woollard, Ewing, and Johnson, 1938; Woollard, 1939, 1940a, 1941, 1943, 1944, and 1948). One of the early papers that dealt with gravity interpretations of subsurface geology in the Atlantic region was that on the Bahamas by Hess (1933, p. 38-53). He concluded "that the general field of negative anomalies is due to a great thickness of light sediments beneath the Bahamas, but that the dolomitic reef material is relatively heavy, thus making the anomalies on the reef material less negative than those over the submarine valleys." Many years later, Worzel and Shurbet (1955a, p. 97) estimated the great thickness of light sediments beneath the Bahamas to be 93,000 feet. In addition, they stated (p. 97), "If this calcareous system were laid down on an oceanic crust, and approximate isostasy were maintained at all times, the final 16,000 feet would have been laid down in water depths less than 2,000 feet." Other papers that make geological interpretations from gravity measurements along the Atlantic Coast include those of Woollard (1940b and 1949), Skeels (1950), Worzel and Shurbet (1955b), and Worzel, Ewing, and Drake (1953). A summary map of Bouguer gravity anomalies along the Atlantic Coast has been published recently by Woollard and Joesting (1964) and is discussed briefly in the following paragraphs.

The regional Bouguer gravity anomalies along the Atlantic Coast are shown on plate 7, which has been adapted from the Bouguer Gravity Anomaly Map of the United States (Woollard and Joesting, 1964). These anomalies reflect primarily compositional differences at considerable depths in the earth's crust, but are related to some extent to the structure and composition of the Coastal Plain sedimentary rocks and shallow basement. Four alternating belts of predominantly positive and predominantly negative gravity anomalies extend diagonally across the region from southwest to northeast. These correspond roughly with the continental rise and slope, the Continental Shelf and Coastal Plain, the Appalachian Mountain System Front, and the Piedmont Plateau-Blue Ridge-Appalachian Basin region.

Continental Rise and slope

Positive gravity values extend over a wide area parallel to the outer Continental Shelf and increase rather regularly oceanward across the continental slope and rise. They range from 0 to 40 milligals along the outer Shelf to more than 300 milligals near the boundary between the continental rise and the abyssal plain (fig. 1). A single, slightly negative anomaly about 20 miles wide and 190 miles long is present off South Carolina. The general increase of positive gravity values oceanward probably reflects a transition between the lighter continental crust and the heavier oceanic crust underlying the ocean basins of the earth.

Continental Shelf and Coastal Plain

Negative gravity values predominate on the Continental Shelf and Coastal Plain, although irregular positive anomalies are numerous and large enough to create a confusing pattern not readily related to known surface and shallow subsurface features. The area is underlain by light continental crust on which are irregularly distributed sedimentary rocks with igneous intrusions and flows at places. In general, the negative values range from zero along the outer Continental Shelf to as little as -40 milligals in small isolated anomalies inland, and back to zero along or near the western limit of the Coastal Plain. In Alabama and from Virginia northward, the western zero-gravity contour is as much as 75 miles inside the Coastal Plain and Continental Shelf. A large, positive anomaly breaks the regional pattern from Alabama across Georgia into the Southeast Georgia embayment (fig. 6). Another positive anomaly crosses the regional pattern in southern Florida, and long reentrants are present in the negative pattern at several places south of Virginia.

The largest unbroken area of negative values in the Coastal Plain and Shelf is a crescent-shaped anomaly more than 100 miles wide and 600 miles long between Cape Hatteras and the Gulf of Maine. Several sizeable negative anomalies are present within the larger one. One in northeastern North Carolina and southeastern Virginia reaches a value of -40 milligals; another of -20 milligals and about 200 to 250 miles long is present in the Coastal Plain and Shelf near Atlantic City, New Jersey. It does not coincide with the Baltimore Canyon trough, although it crosses one arm of this basement feature. The large crescent-shaped negative anomaly as a whole conforms somewhat to the zone of maximum compression in the Appalachian Mountain System. Whether it is related to this, or to Triassic deposition, is not known at this time.

A large area in southwestern Georgia and the Florida Panhandle has negative values that seem to be related somewhat to the composition of the shallow basement rocks. Wells in this area penetrate Paleozoic limestone, sandstone, and shale beds beneath the Mesozoic. The outline of the area underlain by these Paleozoic rocks conforms in a rough way with the zero contour from Alabama to eastern Georgia, but the relationship becomes vague southeastward in Florida where pre-Mesozoic volcanics are found in some wells.

Appalachian Mountain front

Positive gravity values ranging from zero to 50 milligals form a narrow belt 30 to 80 miles wide along the front of the Appalachian Mountain System. This belt parallels the Blue Ridge Province in Virginia and the Newark Basin in New Jersey (Tectonic map of the United States, U. S. Geol. Survey and Am. Assoc. Petroleum Geologists, 1962), but does not conform well to geologic and physiographic boundaries throughout its length. It cuts diagonally across the Piedmont Plateau southward to Alabama and continues beneath the Coastal Plain to the Florida Panhandle. It also encroaches on the Coastal Plain and Continental Shelf northward from Virginia to the Gulf of Maine. The exposed rocks within this belt are mainly Paleozoic metamorphics, including those in the Carolina Slate Belt (Tectonic map of the United States, U. S. Geol. Survey and Am. Assoc. Petroleum Geologists, 1962).

Piedmont Plateau, Blue Ridge, and Appalachian Basin

West of the belt of positive gravity values along the front of the Appalachian Mountain System is a broad expanse with negative gravity anomalies ranging from zero to -100 milligals. The minimum anomalies of -100 milligals are present in the Blue Ridge Province in northeastern Tennessee and northwestern North Carolina, where according to King (1964, p. 19) the -80 milligal contour encloses all the major windows of the thrust sheets of the Southern Appalachians. King suggests that these data indicate that the "surface Precambrian rocks of the southwestern segment of the Blue Ridge province are underlain by a thick body of overridden, deformed Paleozoic and possibly earlier sedimentary rocks." Minimum values of -80 milligals are present in anomalies within the Appalachian Basin, which contains considerable thicknesses of unmetamorphosed Paleozoic sedimentary rocks.

Regional magnetic anomalies

Coastal Plain

Magnetic observations on the Coastal Plain date back to the early 1930's (MacCarthy, Prouty, and Alexander, 1933; MacCarthy and Alexander, 1934; Jenny, 1934; Johnson and Straley, 1935; and MacCarthy, 1936). Jenny (1934, p. 413) found northeast magnetic trends in the Coastal Plain of Alabama and Florida and related them to the Appalachian Mountain System, as did Lee, Schwartz, and Hemburger (1945) later. MacCarthy (1936, p. 405, 406) drew similar conclusions about subparallel high and low intensity trends in the Coastal Plain of North and South Carolina. He noted also that these trends curve around the southeastward-trending basement uplift (Cape Fear arch) at Wilmington, discussed earlier by Stephenson (1926, p. 891); that they outline a subsurface Triassic basin near Florence, South Carolina; and that they indicate a distinct change in basement slope near and parallel to the coast.

Maps of vertical magnetic intensity anomalies on the Coastal Plain of North Carolina were published by Skeels (1950, pls. 3 and 4) after the drilling of the deep well at Cape Hatteras (NC-14) in 1946. He compared these with gravity maps (ibid., pls. 1 and 2) and seismic maps (ibid., figs. 3, 19, and 20) of the same area, and noted that both the magnetic and gravity anomalies (ibid., fig. 2) showed north-to-south trends. His conclusions were that the magnetic maps tend to accentuate effects from the upper part of the basement more than do the gravity maps, and that the magnetic properties of the igneous rocks seem to be much more variable than does the density.

In 1959, Elizabeth R. King (1959, fig. 1) published a regional magnetic map of Florida, from which the structural trends of the Precambrian and Paleozoic rocks beneath the Coastal Plain were inferred. Two regional magnetic trends dominate the map. One extends southeasterly from the Florida Panhandle along the southwest side of the peninsula and across the tip of southern Florida toward the Bahama Islands. The second, parallel to the Appalachian Mountain System, crosses northeastern Florida and seemingly is intersected by the first one at the Gulf Coast. Small non-linear anomalies, possibly due to intrusive rocks, separate the two trends in central eastern Florida. King's conclusions, similar to those of Woollard (1949) based on gravity, suggested that the southeasterly trend is a continuation of the Ouachita Mountain System, whose subsurface extension in Alabama and relationship to the Appalachian Mountain System has been the subject of much discussion (King, P. B., 1950, p. 667-668).

Continental Shelf and slope

Magnetic observations on the Continental Shelf and slope were reported first in 1954 by Keller, Meuschke, and Alldredge (1954), who discussed two aeromagnetic profiles from Fire Island, New York, to Bermuda, and from Ludlam Beach, New Jersey, to Bermuda. They recognized a linear magnetic anomaly near the edge of the Shelf and attributed this to an igneous intrusion, about 48 kilometers wide, into the basement parallel to the coast. This magnetic anomaly at the Shelf edge was noted also by Miller and Ewing (1956, p. 412), Drake, Ewing, and Sutton (1959, p. 175), and Heezen, Tharp, and Ewing (1959, p. 51).

An analysis of ten aeromagnetic profiles across the Shelf and slope by King, Zietz, and Dempsey (1961) [p. D302,303] established that the anomaly along the outer edge of the Shelf corresponds in position with the basement ridge found by seismic refraction (Drake, Ewing, and Sutton, 1959), but that the intensities do not correspond with depth to basement. The conclusion was drawn that although basement topography may have some effect on the magnetic intensity, the anomaly "may be at least partly the expression of a large mass or series of masses of more magnetic rocks within the basement -- possibly intrusive bodies along a zone parallel to the continental margin at the transition from a continental to an oceanic crust." (p. D303).

A marine magnetic survey by the U. S. Naval Oceanographic Office (1962) provided data on the magnetic anomaly at the Shelf edge between latitudes 34°30'N. and 39°00'N. Conclusions from this survey supported the idea that the anomaly is an expression of a large mass of more highly magnetic rocks in the basement.

Farther north off Nova Scotia, marine magnetic surveys have indicated a broad, low-intensity magnetic anomaly beneath the Shelf edge southeast of Sable Island (Bower, 1962, p. 8). The bathymetric position of this anomaly is similar to that of the one found by Keller, Meuschke, and Alldredge (1954), off the east coast of the United States. Bower (1962, p. 8) believes that the magnetic anomaly near Sable Island could be produced by a large intrusion buried beneath thousands of feet of non-magnetic material. The surveys off Nova Scotia offer no basis for disagreement with seismic evidence (Press and Beckman, 1954, p. 308) for large thicknesses of sedimentary rocks beneath the Shelf in this area.

In 1963, the numerous magnetic observations on the Continental Shelf and slope were summarized and the anomaly trends plotted on a chart by Drake, Heirtzler, and Hirshman (1963). Plate 8 shows these high intensity trends with significant regional trends labelled for this review. The width of the trend lines indicates amplitude, not the width, of the anomaly. The anomalies are attributed primarily to compositional differences within the basement, yet these differences are alined so as to carry certain connotations of regional tectonics.

Long, linear southwesterly trends, despite their crossing and branching at places, roughly parallel the Appalachian Mountain system and the edge of the Shelf. This dominant pattern is indicated on plate 8 as the "Appalachian trend." The Appalachian trend terminates in Florida against a southeasterly magnetic trend that Elizabeth King (1959) has suggested as an extension of the Ouachita Mountain system, and is indicated on plate 8 as the "Ouachita(?) trend." The Ouachita trend extends from the vicinity of Tallahassee in northwestern Florida along the southwest coast and across southeastern Florida near Miami to the Bahama Islands. Its identity is lost there in arcuate patterns, perhaps related to an intersection with slope anomaly(?) A of plate 8.

The dominant Appalachian trend is interrupted along the 40th parallel, about 50 miles south of New York, by a linear anomaly more or less alined with a string of sea mounts extending down the continental rise to the abyssal plain (see pl. 8). This anomaly has been interpreted by Drake, Heirtzler, and Hirshman (1963, p. 5270) as a transcurrent fault in the basement with right lateral displacement of about 100 miles and a total length in excess of 600 miles.

The large anomaly along the edge of the Continental Shelf, commonly referred to as the "slope anomaly," extends from north of Halifax (Bower, 1962, p. 8) to Cape Fear (pl. 8) with one offsetting interruption by the transcurrent fault(?) trend near New York. South of Cape Fear, the slope anomaly branches with one trend (slope anomaly A, pl. 8) continuing parallel to the edge of the Blake plateau and the other (slope anomaly B, pl. 8) extending subparallel to the coast to its termination against the Ouachita(?) trend. Seismic data south of Cape Fear are not sufficient to relate these trends to basement ridges as is possible north of Cape Fear. Either trend A or B may reflect a basement ridge connecting to the basement ridge to the north. If slope anomaly B connects, the basement ridge to the north presumably is related to the Appalachian system in origin. If slope anomaly A connects, the basement ridge may be a feature of continental margins.

Recently, Watkins and Geddes (1965) reported on the slope anomaly between Cape Hatteras, North Carolina, and Cape May, New Jersey, where it is 30 to 80 kilometers wide with peak intensities generally 350 gammas more than those of adjacent areas. From comparison of this anomaly to some along the Aleutian Island chain and across the island of Puerto Rico, they drew the inference that the basement ridge along the Atlantic Shelf is a buried, quiescent island arc and that the slope anomaly reflects intrusive and extrusive phases of volcanism during the active tectonic development of the island arc (p. 1357).

Principal structural features

The principal structural features of the Atlantic Coastal Plain and Continental Shelf that can be outlined by contours on the basement rocks are shown on plate 4. Named features beyond the limits of the basement contours can be located on figure 6. The principal structural features are discussed briefly in the following paragraphs; for fuller discussion see Stephenson (1928), Eardley (1962, p. 135-153), and Murray (1961, p. 92-98).

Figure 6 near here

Cape Fear arch

The Cape Fear arch is a southeastward plunging basement nose, the axis of which intersects the North Carolina coastline near Cape Fear. Variously known as the Great Carolina ridge, Wilmington anticline, Carolina ridge, or as used in this report, the Cape Fear arch, it is the most prominent structural feature of the central part of the Atlantic Coastal Plain. It is observable in the Cretaceous outcrop pattern, well data, magnetometer surveys (MacCarthy, 1936, p. 405), and seismic surveys (Bonini, 1955, p. 1533; 1957; Meyer, 1957). The general shape is in the form of a gentle warp, with the axial plunge increasing sharply near the shoreline and gradually diminishing updip toward the Fall Line. Along the axis of the arch from the Fall Line to the coast the basement rocks dip at an average of about 13 feet per mile. The arch is asymmetric in cross section, with the north limb the steeper. Lower Cretaceous rocks and some Upper Cretaceous rocks are missing from the crest of the feature, but are present on the flanks.

Seismic information (Meyer, 1957, p. 81; Hersey, Bunce, Wyrick, and Dietz, 1959, p. 445) indicates that the Cape Fear arch protrudes seaward across the Continental Shelf as a large regional nose in the basement rocks. At the crest of the arch on the coastline, the basement rocks are present at a depth of about 1,100 feet. The basement rocks slope off to depths of 5,000 feet at Cape Lookout, North Carolina, at the north, and 2,500 feet at Cape Romain, South Carolina, on the south. At the edge of the Continental Shelf, the basement rocks on the crest of the arch are 4,000 feet below sea level.

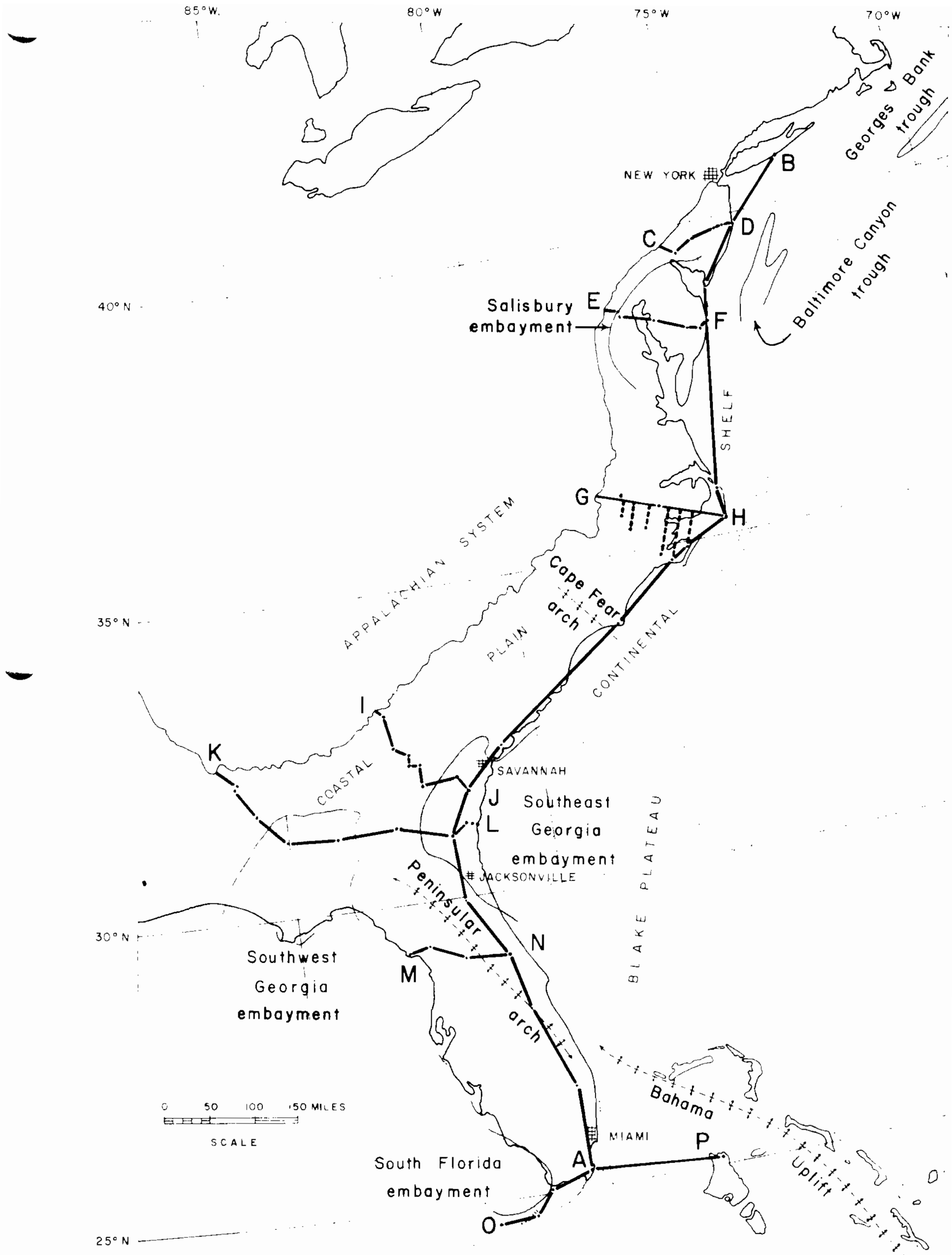

FIGURE 6. INDEX MAP OF ATLANTIC COASTAL PLAIN AND CONTINENTAL SHELF SHOWING PRINCIPAL STRUCTURAL FEATURES AND LINES OF CROSS SECTIONS

The formation of the Cape Fear arch is thought to have been accompanied by down-warping of the flanks, which Cooke (1936, p. 158) believed took place during late Eocene time. Other geologists have dated the origin at different times ranging from early Cretaceous to early Miocene. Both Siple (1946, p. 37) and Eardley (1951, p. 131) have suggested that uplift and erosion probably occurred during more than one stage.

Peninsular arch

The dominant subsurface structural feature of Florida and southeastern Georgia is the Peninsular arch. It has a southeast trend and extends from southern Georgia down the axis of the Florida peninsula (Applin, 1951, p. 3; Toulmin, 1955, p. 210). The structure was topographically high in Early Cretaceous and early Late Cretaceous time during which sediments were deposited around it, but not over it -- beds of Austin age rest on Paleozoic rocks in places on the crest. A later (Miocene) auxiliary uplift occurred on the southwest flank of the Peninsular arch, which has been called the Ocala uplift. The north slope of the Peninsular arch marks the southern boundary of the Southeast Georgia embayment.

Southwest Georgia embayment

The Southwest Georgia embayment encompasses parts of southwestern Georgia, southeastern Alabama, and the Florida Panhandle between the Chatahoochee uplift of Alabama and Georgia and the Peninsular arch. It appears to be a relatively shallow reentrant in the Upper Cretaceous (Austin) rocks, as shown by the Tectonic map of the United States (U. S. Geol. Survey and Am. Assoc. Petroleum Geologists, 1962). However, it is quite prominent in the older sedimentary and basement rocks. The contained sedimentary rocks exceed 7,500 feet in thickness north of the Florida-Georgia boundary and probably exceed 15,000 feet offshore. Considerable thicknesses of Lower Cretaceous rocks have been penetrated by wells in this embayment. The stratigraphy suggests that this embayment was well filled by Lower Cretaceous sediments before Upper Cretaceous rocks were laid down in it.

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Antoine and Harding (1963, fig. 8) have postulated on geophysical evidence the protrusion of the Peninsular arch (Ocala uplift) southwestward into the Gulf of Mexico. They present structure maps (Antoine and Harding, figs. 6 and 7) showing this in Cretaceous rocks as well as in the basement rocks. If this is the case, the Southwest Georgia embayment is somewhat more constricted offshore than might be expected from the onshore contours shown on plate 4.

Bahama uplift

A positive structural element extending northwestward through the Bahama Islands was inferred first by Hess (1933, p. 42-45, and fig. 9) from the submarine topography and gravity measurements in that region. He believed that the formation of the long, parallel northwestward-trending submarine valleys between the Islands had been controlled by folded sedimentary formations, rather than by faulted structures. Hess pointed out the need for further geophysical data to determine whether or not the folded Appalachians, or a branch of them, extend under the Bahama region. The same gravity data with many more contributed by oil companies were interpreted in 1959 by Talwani, Worzel, and Ewing (1959, p. 159) as indicative of graben-like downfaulting along the same trend.

In 1947, Pressler (1947, p. 1858) suggested on the basis of the sea-bottom configuration "that the Florida peninsula is bounded on the east and south by major fault zones, and that the Bahaman and Cuban areas are very large faulted segments of the Gulf of Mexico plate or basin." His sketch map (Pressler, 1947, fig. 1) indicated an anticlinal flexure, which he named the <u>Bahama uplift</u>, plunging northwestward through the eastern rim islands of the Bahama group toward Cape Kennedy (See fig. 6) and terminating against a major fault zone at the edge of the Continental Shelf. Pressler (1947, p. 1853) also suggested a probable close relationship between the Bahama uplift and the southeast-trending basement ridge now known as the Peninsular arch.

In 1961, Murray (1961, p. 101) agreed with earlier concepts in stating that "crystalline and sedimentary rocks of Paleozoic age probably exist beneath the Bahama Islands and form the backbone on which the sedimentary sequence of the islands has accumulated." At the present time, no conclusive geophysical evidence has been published, although it may exist in oil company files, and the one deep well (14,585 feet deep) on Andros Island is insufficient to outline the form or prove the existence of the Bahama uplift.

South Florida embayment

The South Florida embayment as described by Pressler (1947, p. 1856) embraced the synclinal area between the Peninsular arch, the Bahama Islands, and Cuba. The axis was believed to extend "along a general line through Great Inagua Island to a point near the south end of Andros Island, thence across the Bahama Banks to the Florida Keys near the north end of Key Largo and across Dade and Monroe Counties to the southwest coast of Florida." Patton (1954, p. 160) restricted the term to the area between the south flank of the Ocala uplift, a Tertiary feature offsetting the Peninsular arch, to the Straits of Florida just south of the Florida Keys. Murray (1961, p. 101) followed Pressler's geographic name and description of the area, but referred to the feature as a basin rather than an embayment. Applin and Applin (1965, p. 15 and 16) point out that data revealed by deep wells drilled among the Florida Keys since Pressler's contribution in 1947 have led to a restriction in the southeastern extent of the embayment. They apply the term "South Florida embayment" to the negative area whose axis "trends about N.65°W. from the eastern end of Florida Bay across the southern tip of the Peninsula and plunges toward the Gulf of Mexico." Oglesby (1965) has presented six structure and thickness maps showing hypothetical closure of the embayment beneath the Gulf of Mexico to form what he terms the "South Florida basin." There is not much evidence for or against this speculation at this time.

The position of the South Florida embayment as now known is shown in figure 6. It is well reflected by known thicknesses of Upper Cretaceous and Cenozoic rocks in and adjacent to Florida Bay. The basement configuration in this area is not known at present.

Southeast Georgia embayment

The Southeast Georgia embayment (Toulmin, 1955), also termed the Okefenokee embayment (Pressler, 1947, p. 1856), is recessed into the Atlantic Coast between Savannah, Georgia, and Jacksonville, Florida. It interrupts the long, uniform slope of the basement off the south flank of the Cape Fear arch and extends southwestward to the Peninsular arch. This embayment is primarily a tectonically passive feature, although it may have undergone some downwarping on the Continental Shelf, where the contained rocks exceed 10,000 feet in thickness. Recently, Murray (1961, p. 96) used the term "Savannah basin" in lieu of Southeast Georgia embayment, but extended the northern limit to the Cape Fear arch in South Carolina so that the terms are not synonymous.

A basement ridge, the Yamacraw ridge, was described from seismic studies by Meyer and Woollard (1956); Meyer (1957, p. 71); and Woollard, Bonini, and Meyer, (1957, p. 49) as a southwestward projection into the embayment about 15 to 30 miles inland from the coast. A later, more detailed seismic survey by Pooley (1960, p. 21) confirmed the existence of an elongate seismic anomaly but located its axis at the coastline between Parris Island, South Carolina, and Sea Island, Georgia. Pooley (1960, p. 21, and pl. 2) depicts this anomaly as a basement ridge, not reflected in the overlying beds, about 110 miles long and 40 miles wide, with more than 1,000 feet of relief. Data from subsequently drilled wells at the southern extremity of the anomaly do not substantiate these dimensions. However, they do not necessarily preclude the existence of a relatively minor structural nose in the basement rocks farther north near the South Carolina border.

9.1267

Salisbury embayment

The name "Salisbury embayment" was applied by Richards (1948, p. 54) to the low area in the basement rocks between Washington, D. C., and Ocean City, Maryland, without definite north or south limits. Additional well and seismic data (Tectonic map of the United States, U. S. Geol. Survey and Am. Assoc. Petroleum Geologists, 1962) suggest now that the Salisbury embayment is a reentrant on the basement rocks from a line drawn westward from Newport News, Virginia, along the James River to a line drawn westward to the piedmont from Atlantic City, New Jersey. This embayment is fairly prominent in the basement rocks, but loses form in the younger beds, which suggests that it is a pre-Cretaceous feature almost filled by Cretaceous sedimentation. At the coastline in Delaware, it contains about 10,000 feet of Mesozoic and Cenozoic rocks.

This feature is a part of the much larger Chesapeake-Delaware embayment of Murray, 1961, p. 92), which includes a large portion of the geosynclinal province north and east of the Cape Fear arch to the Grand Banks off Newfoundland. Despite the fact that both the Chesapeake and Delaware Bays from which the name is derived are located within the more restricted Salisbury embayment, the newer name does not supercede the term "Salisbury embayment."

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Baltimore Canyon trough

Published seismic work (see Drake, Ewing, and Sutton, 1959, fig. 29) has revealed a long, narrow trough in the basement rocks off the New Jersey and Delaware coast. According to the Tectonic map of the United States (U. S. Geol. Survey and Am. Assoc. Petroleum Geologists, 1962), the basement rocks descend below sea level from 10,000 feet near the mouth of Delaware Bay to more than 16,000 feet about 40 miles offshore and then rise to somewhat less than 10,000 feet at the edge of the Continental Shelf before dropping abruptly to 20,000 feet beneath the continental slope. The trough, as outlined by the 10,000 foot contour, parallels the Shelf edge for about 150 miles from a latitude of about 40° N. to about 38°N., where it apparently crosses the Shelf edge to the slope. Along its western side, it exhibits a bulge landward toward Delaware Bay. This bulge corresponds somewhat to the much wider Salisbury embayment on land.

Inasmuch as this relatively unexplored trough is important not only to the continental history, but also perhaps to petroleum exploration yet to come, this negative feature has been designated the Baltimore Canyon trough (Maher, 1965, p. 6). Baltimore Canyon is a submarine physiographic feature shown on the U. S. Coast and Geodetic Survey Nautical Charts 1108 and 1109 at the approximate location where the trough intersects the edge of the Shelf.

Georges Bank trough

A long, canoe-shaped trough in the basement rocks off Cape Cod has been found by geophysical programs of oceanographic institutions (see Drake, Ewing, and Sutton, 1959, fig. 29). This trough is completely enclosed by the 10,000-foot contour shown on the Tectonic map of the United States (U. S. Geol. Survey and Am. Assoc. Petroleum Geologists, 1962), and does not reach 15,000 feet in depth. It is about 215 miles long and 25 to 30 miles wide in places. Seismic velocities suggest that it also contains Mesozoic and Cenozoic rocks. The name "Georges Bank trough" has been used for identification (Maher, 1965, p. 6) because of its close proximity and subparallelism to Georges Bank, a submarine physiographic feature shown on U. S. Coast and Geodetic Survey Nautical Charts 1107 and 1108.

Emerald Bank trough

As a result of their refraction seismic investigations, Officer and Ewing (1954, fig. 6) have reported an oval-shaped trough in the crystalline basement beneath the Continental Shelf about 120 to 150 miles off Halifax, Nova Scotia (See pl. 4). Its axis crosses the 62°W. long. meridian at approximately 43°15'N. lat. (pl. 4) near Emerald Bank, (See U. S. Hydrographic Chart 6610), for which it is herein named. The east end has not been defined by seismic work, but assuming that the 10,000-foot contour closes eastward about as it does westward, the trough may be as much as 120 miles long and 40 miles wide. The basement rocks off Halifax slope very gently from shore to a depth of 8,000 feet, then descend to 14,000 feet and rise to 10,000 feet before dropping abruptly to 20,000 feet beyond the Shelf edge. Seismic velocities suggest that this basin is filled with consolidated sediments that Officer and Ewing (1954, p. 664) regard as most likely to be Triassic in age. Woollard, Bonini, and Meyer (1957, p. 70) agree that the consolidated sediments could be Triassic, but believe that they are more likely Paleozoic in age. The overlying semiconsolidated and unconsolidated rocks thought to be Cretaceous and Cenozoic in age respectively do not seem to reflect the underlying structure or topography (Officer and Ewing, 1954, fig. 2).

Stratigraphy

by J. C. Maher and E. R. Applin

Regional setting

The Appalachian Mountain System, a highland of Paleozoic and older rocks, extends almost the full length of eastern North America (pl. 4). It consists of the Blue Ridge -- a narrow anticlinorium of early Paleozoic and Precambrian rocks extending from Pennsylvania to Georgia -- and the Crystalline Appalachians -- a long, broad belt of intensely deformed and intruded Paleozoic rocks extending from the Canadian Maritime Provinces to Alabama.

Triassic, Cretaceous, and Tertiary rocks flank the Crystalline Appalachians from New York southward and crop out roughly parallel to the present Atlantic coastline (pl. 4). Triassic outcrops are confined to scattered down-faulted basins within the piedmont. Lower Cretaceous outcrops are recognized in part of the Salisbury embayment (~~Geologic map of the United States~~ Stose, 1932) and may be represented farther south as thin clastic beds mapped with the basal Upper Cretaceous. Upper Cretaceous rocks crop out almost continuously along the Fall Line from eastern Alabama to the north flank of the Cape Fear arch in North Carolina, and from Virginia to New York. Tertiary rocks crop out in broad patterns throughout the Coastal Plain except on the Cape Fear arch and where masked by a veneer of alluvial deposits.

The Cretaceous and Tertiary rocks exposed from southern Georgia northward to Long Island are mainly nearshore marine and continental clastics interspersed with some thin lignitic layers and marl beds. Seaward, these rocks become marine in character and thicken to more than 10,000 feet at the coastline. Cretaceous rocks do not crop out in Florida and southern Georgia ~~and Florida,~~ and only part of the Tertiary sequence is exposed in that area. Both are dominantly marine carbonates in the subsurface and exceed 15,000 feet in thickness in the Florida Keys and Bahama Islands. The marine carbonate units in southern Georgia and Florida, though less distinctly separable lithologically, are more uniform in character and thickness and more susceptible to paleontologic dating than the clastic beds farther north along the coast. In addition, much more subsurface control is available from the more than 300 wells drilled in Florida alone.

Little is known of the lithologic aspects of the rocks beneath the Continental Shelf, as no deep tests have been drilled offshore. However, refraction seismograph surveys indicate the possibility of thicknesses of more than 10,000 feet in several offshore negative features of the basement rocks. The Baltimore Canyon trough off New Jersey may contain more than 15,000 feet of sedimentary rocks. The Georges Bank trough off Cape Cod is thought to contain over 10,000 feet of sedimentary rocks. The fact that more than 10,000 feet of shelf-type sedimentary rock is present in the Cape Hatteras well suggests that similar types of rocks could be present farther out on the Shelf in these troughs.

The basement surface upon which Mesozoic rocks were deposited appears to be relatively smooth, having well-rounded topographic features and few structural irregularities. Not enough wells have been drilled to be certain of this, but the few well records available and published seismic work suggest a gentle slope of about 15 feet a mile from the outcrop to a depth of about 3000 ~~2,500~~ feet. Below this depth the slope steepens somewhat sharply to more than 100 feet a mile.

The basement rocks are primarily igneous and metamorphic rocks of Precambrian and Paleozoic age. These include a wide variety of granite, diorite, gneiss, schist, tuff, volcanic ash, rhyolite porphyry, gabbro, basalt, and diabase. The basic igneous intrusives are found in both Paleozoic and Triassic rocks, and in some wells the Triassic intrusives have been regarded incorrectly as pre-Mesozoic basement. Paleozoic sedimentary rocks ranging from Early Ordovician to Middle Devonian in age are present in the basement in northern and western Florida and southern Georgia (Applin, 1951, p. 11-15; Bridge and Berdan, 1951, 1952; Carroll, 1963).

Submarine outcrops and bottom deposits

The first knowledge of submarine outcrops of the Coastal Plain strata along the Atlantic Coast came from rocks dredged by trawlers along the Grand Banks, Banquereau, and Georges Bank. These were collected in 1878 by Upham (Verrill, 1878, p. 324) in the service of the U. S. Fish Commission at Gloucester, Massachusetts, and were reported by Verrill (1878, p. 323) and Upham (1894, p. 127) to contain Tertiary fossils. Much later, Dall (1925) reviewed and revised the paleontology of these rocks and noted Late Cretaceous species in one boulder from Banquereau (p. 215). He expressed "little doubt that Late Cretaceous and Tertiary fossiliferous deposits originally existed along the northeastern coast from Newfoundland southward, as far as the area of glaciation extended, though in most cases the only evidence remaining is the presence in the glacial debris of fragmentary portions of the original deposits." (p. 213).

Bottom deposits along the Atlantic Coast were first known from ship soundings, storm deposits on the beaches, and sediments accidently dredged in fishing and anchoring operations. Pebbles and boulders of granite, gneiss, and schist found in nets and lobster traps gave early evidence of glacial debris on bottom in the fishing grounds. Pourtales (1850, 1854, 1871, 1872), and Bailey (1851, 1854) produced much of the early information about the sea bottom along the Atlantic Coast. As early as 1879, the U. S. Coast and Geodetic Survey (Mitchell, 1879) published bottom studies of the Gulf of Maine pointing out the presence of pebbles and small stones on the top of Georges Bank.

Agassiz (1888, p. 260-293) discussed submarine deposits and presented a map (fig. 191) of bottom sediments in the Gulf of Mexico, Caribbean Sea, and western Atlantic Ocean. Later publications concerning bottom sediments along the Atlantic Coast are numerous and detailed. Some of the more recent ones that can supply further references and details not pertinent to the scope and purpose of this report are those written by Burbank (1929), Alexander (1934), Stetson (1938), Hough (1940), Hough (1942), Sanders (1958), Moore and Gorsline (1960), Wigley (1961a, 1961b), McMaster (1962), Moore and Curray (1963), Schlee (1964), Gorsline (1963), Pilkey (1964), Uchupi (1964), Stewart and Jordan (1964), Emery, Merrill, and Trumbull (1965), Emery, Wigley, and Rubin (1965), Nota and Loring (1964), Merrill, Emery, and Rubin (1965), and Pratt and McFarlin (1966).

Systematic investigations of subbottom sediments and strata along the Atlantic Coast by means of dredging, coring, and undersea photography were begun about 1930 by several oceanographic institutions. Large quantities of data have been accumulated in these continuing programs. Data on the composition and age of samples and cores have been reported by many workers including Shepard, Trefethen, and Cohee (1934), Shepard and Cohee (1936), Bassler (1936), Cushman (1936, 1939), Stephenson (1936), Stetson (1936, 1938, 1949), Northrop and Heezen (1951), Ericson, Ewing, and Heezen (1952), and Heezen, Tharp, and Ewing (1959). The regional aspects of bottom sediment and submarine outcrop distribution in the Atlantic Ocean are discussed at length by Ericson, Ewing, Wollin, and Heezen (1961), and Uchupi (1963). Detailed studies of samples and photographs of the bottom of the Tongue of the Ocean in the Bahama Islands have been reported by the Marine Laboratory, University of Miami (1958), Busby (1962a, b, and c), and Athearn (1962a, b). The location and age of samples and cores listed in these publications are shown on plate 2.

Artesian submarine springs off the Florida coast have provided some stratigraphic and structural information about the upper strata of the Shelf. Rude (1925) described an oceanic spring about $2\frac{1}{2}$ miles east of Crescent Beach near St. Augustine (pl. 2). This spring and another in the Gulf of Mexico about 500 feet west of Crystal Beach in Pinellas County are the only ones that have been charted (U. S. Coast and Geodetic Survey Charts 3258, 1111, and 1257), although others have been reported along the east coast between lat 28°N. and 30°N. (Stringfield, 1964, written commun.). Stringfield and Cooper (1951) made a detailed report on the geological and hydrological features of the spring in the Atlantic Ocean off Crescent Beach. Sobieralski (<u>in</u> Rude, 1925) described the spring as follows:

"The ocean bed in the vicinity of the spring is comparatively level and about 55 feet deep, composed of fine gray sand. The spring emerges from a hole only about 25 feet in diameter and 125 feet deep or 69 feet below the bed * * *

"To the northeast of the center of this spring, the hole is enlarged to a diameter of about 300 feet; this shape of the enlarged hole probably directs the current from the spring in the northeasterly direction noted on the surface."

Stringfield and Cooper (1951, p. 63) point out the similarity in shape of this submarine spring to those discharging through sink holes formed during Pleistocene time when the sea stood at lower levels. They conclude that the aquifer is the Ocala Limestone of upper Eocene age and the confining beds, about 100 feet thick at the spring, are the Hawthorn Formation of Miocene age and younger deposits. The artesian head at the spring cannot be measured, but must be in the order of 25 to 30 feet above sea level judging by the 30-foot head in Ocala wells at nearby Crescent Beach. The chloride content of the spring water has not been accurately determined because of sampling difficulties. It would be safe to assume it is in excess of 4,000 parts per million, the chloride content of water from wells at Crescent Beach. The temperature measured at a depth of 121 feet over the spring was 71.5°F; that at the ocean surface ranged from 62° to 64°F. Temperatures of water from Ocala wells onshore range from 74° to 82°F, which suggests that the reading at the bottom of the spring is low due to admixture of cooler sea water (Stringfield and Cooper, 1951, p. 69).

Shoals marking the seaward continuation of outcrops onshore also provide important clues to the structural attitude and stratigraphic sequence of beds forming the top of the Shelf. ~~The Trenton~~ Marls of lower Miocene age crop~~s~~ out on the fishing banks known as "Black Rocks" off the coast of North and South Carolina (Pearse and Williams, 1951). These banks range from close inshore out to a depth of about 20 fathoms, or 120 feet, where the Cape Fear arch plunges seaward. They appear to represent the underwater continuation of Miocene strata around the nose of this structure.

An interesting limestone outcrop of unknown age has been photographed at a depth of 1,000 fathoms, or 6,000 feet, in the Tongue of the Ocean (see fig. 2) of the Bahama Islands (lat 24°41'49"N., long 77°35'01"W.). According to Busby (1962B, p. 5-12), this indurated limestone outcrop is 24 feet long with a sharp scarp three feet high striking northeast as a smooth vertical to concave wall. The limestone has depressions or cavities, two to 24 inches across and as much as 12 inches deep. In many instances, the bottom of the cavity is covered with unconsolidated sediment. Some cavities are interconnected to form a network of channels, and most have sharp, angular rims. Busby concludes that the features of this outcrop have resulted from solution in a subaerial or littoral environment with subsequent lowering to its present depth. He mentions the possibility that this outcrop may be a slump block from the surrounding platform, but inclines toward the view that the outcrop is in place and has been lowered about 6,000 feet to its present depth either by gradual subsidence or block faulting.

Busby (1962C, p. 61) reports also that an outcrop of well-lithified calcareous material or semilithified bottom material has been photographed at lat 23°27.4'N., long 76°58.8'W. in the cul-de-sac of the Tongue of the Ocean. The outcrop of indeterminable thickness strikes northeast at a depth of 4,020 feet. In one photograph, a slab of outcropping material appears to have moved, or is now moving, in a southerly direction. Steep-sided circular pits or depressions a few centimeters in depth and diameter are visible in other photographs.

Pre-Mesozoic submarine outcrop

The oldest rock recovered from the sea bottom along the Atlantic Coast has come from the granite pinnacles of late Paleozoic-to early Mesozoic(?)-age (Toulmin, 1957, p. 914) at a depth of about five fathoms on Cashes Ledge near the middle of the Gulf of Maine (pl. 2 and fig. 2). This granite is similar in composition to the Quincy Granite exposed in large areas of nearby eastern Massachusetts and Rhode Island. LaForge (1932, p. 35) considered the Quincy Granite to be either Devonian or Mississippian in age.

Cretaceous submarine outcrops

Rocks of Cretaceous age have been dredged from the east walls of Oceanographer and Gilbert Canyons off Georges Bank and from the escarpment of the Blake Plateau opposite Cape Kennedy (pl. 2 and fig. 2). In addition, cobbles of chalk containing Cretaceous Foraminifera have been found in a core from the floor of Northeast Providence Channel, 11,096 feet beneath the sea between the Bahama Islands, and reworked Cretaceous Foraminifera have been identified in a core of coarse glauconitic sand on the continental rise, 155 miles southwest of Cape Hatteras (Ericson, Ewing, and Heezen, 1952, p. 503, 505). The cobbles and sand containing Cretaceous Foraminifera suggest that Cretaceous beds crop out in the canyon walls in the Bahamas and possibly along the Shelf or slope in the vicinity of Cape Hatteras. The suggested presence of Cretaceous beds in the Bahama canyon walls is supported indirectly by the log of the 14,585-foot well (BA-2, pl. 1, table 1) drilled on Andros Island. This well was drilled only a few miles inland from Northeast Providence Channel. It penetrated Upper Cretaceous rocks at a depth of about 8,220 feet and Lower Cretaceous rocks at about 10,760 feet. The latter depth is very close to the maximum depth (1,800 fathoms) of the canyon floor opposite the well site.

<u>Rocks of Woodbine(?) age</u>:--The oldest Cretaceous rock recovered from the sea bottom is a core from the escarpment of the Blake Plateau (lat 28°52'N., long 76°47'W.) opposite Cape Kennedy at a depth of 1,745 meters or 5,724 feet (Ericson, Ewing, Wollin, and Heezen, 1961, p. 236). This core consists of dark grayish-green slightly sandy lutite containing Foraminifera which, according to Loeblich (<u>in</u> Ericson, Ewing, Wollin, and Heezen, 1961, p. 236), are Cenomanian and a little younger than the surface Washita in Texas and Oklahoma. Inasmuch as the Cenomanian stage of Europe straddles the Lower and Upper Cretaceous boundary and includes rocks of both Washita and Woodbine age in North America, the lutite in the core appears to be Woodbine in age.

<u>Rocks of Taylor age</u>:--Rocks of Taylor age have been dredged by Stetson (1949, p. 33) from depths between 596-480 meters (1,955-1,574 feet) and 585-231 meters (1,919-758 feet) along the east wall of Oceanographer Canyon (fig. 2). The dredged material consisted of poorly sorted, coarse-grained, silty sandstone and friable coarse-grained sandstone containing considerable amounts of glauconite and feldspar. Stephenson (1936, p. 369-370) and Bassler (1936, p. 411) identified a Cretaceous fauna from the sandstones, which Stephenson thought corresponded to strata either in the upper part of the Matawan Group or in the lower part of the Monmouth Group. He later (<u>in</u> Stetson, 1949, p. 8) assigned the sandstones to the Matawan Group of New Jersey and Maryland, which is equivalent to the Taylor rocks of the Gulf Coast.

Rocks of Navarro age:--Rocks of Navarro age were dredged by Stetson (1949, p. 33) from depths of 950 meters (3,116 feet) along the east side of Oceanographer Canyon and from 600-530 meters (1,968-1,738 feet) and 758 meters (2,486 feet) along the east side of Gilbert Canyon (fig. 2). The material dredged from Oceanographer Canyon consisted of a dark-colored, partly indurated, micaceous silty clay that contained a Late Maestrichtian or Navarro fauna that Cushman (in Stetson, 1949, p. 10) correlated with the Kemp clay of northeast Texas. The Navarro rocks from Gilbert Canyon consisted of a friable, coarse greensand and limonite-stained, micaceous, fine-grained sandstone containing Foraminifera characteristic of beds of Navarro age (Maestrichtian), according to Cushman (1936, p. 413, and in Stetson, 1949, p. 10).

Tertiary submarine outcrops

Shore cores and dredgings of Tertiary rocks have been recovered at more than three dozen localities concentrated for the most part between Georges Bank and the Hudson Canyon, and in the Blake Plateau-Bahama Banks region (pl. 2 and fig. 2). Recently Marlowe (1965) has reported probable Tertiary sediments from a submarine canyon off Nova Scotia. Paleocene rocks have not been recovered in short cores and dredge hauls along the Atlantic Coast, although they are known to be present beneath the Shelf and Blake Plateau off northeastern Florida (see Offshore test holes) and beneath the Bahama Islands (well BA-2, pl. 1, table 1).

Eocene rocks:--Five shore cores of Eocene marl and chalk have been recovered from the continental slope between Georges Bank and the Bahama Islands. Two cores were taken near the middle of the continental slope about 90 miles southeast of Marthas Vineyard. One by Stetson (1949, p. 33) from a depth of 880 meters or 2,886 feet at lat 39°50'00"N., long 70°48'00"W. contained Foraminifera of Jackson age. The second one nearby, taken by Northrop and Heezen from a depth of 1,000 meters or 3,280 feet at lat 39°50'N., long 70°50'W., was reported by Fox (in Northrop and Heezen, 1951, p. 397-398) to contain Foraminifera commonly found in upper Wilcox, Claiborne, and Jackson beds, but over-all resembling mostly the fauna of Jackson age. D. B. Ericson is quoted by Northrop and Heezen (1951, p. 398) as stating that "the assemblage is not as rich as that in Stetson's core and is slightly older."

Two Eocene cores have been taken from near the base of the continental slope in the vicinity of the Hudson Canyon. Stetson (1949, p. 33) reported that a core from a small gully southwest of Hudson Canyon (lat 38°58'00"N., long 72°28'30"W.) at a depth of 1,565 meters or 5,133 feet contained microfossils identified as an upper Eocene fauna by Cushman (1939, p. 49). This core was rich in Radiolaria as compared to those from the middle of the slope. A second Eocene core from the base of the slope near Hudson Canyon (lat 39°12'N., long 71°48'W.) was recovered from a depth of 2,167 meters or 7,108 feet about 25 miles from the Shelf edge. Ericson, Ewing, and Heezen (1952, p. 502) reported it to be upper Eocene in age and similar to that recovered by Northrop and Heezen (1951) from the continental slope.

A single Eocene core has been reported from the escarpment of the Blake Plateau (lat 29°49'N., long 76°35'W.) at a depth of 1,455 meters or 4,772 feet, by Ericson, Ewing, Wollin, and Heezen (1961, p. 236). They state that Bolli concluded the planktonic species of Foraminifera compare well with those of the upper Eocene Hospital Hill Marl and Mount Moriah Formation of Trinidad.

Oligocene rocks:--Oligocene chalk has been cored by Ericson, Ewing, Wollin, and Heezen (1961, p. 236) on the escarpment of the Blake Plateau (lat 29°12.5'N., long 76°49'W.) at a depth of 2,140 meters or 7,019 feet. Bolli (in Ericson, Ewing, Wollin, and Heezen, 1961, p. 236) compared the assemblage of Foraminifera to that in the *Globigerina ciperoensis* zone of the late or middle Oligocene Cipero Formation of Trinidad.

Miocene rocks:--Miocene rocks have been recovered in 19 tows and cores along the Atlantic Coast. These have come from submarine canyons off Georges Bank, from shoals on the Cape Fear arch, and from the top and edge of the Blake Plateau.

Highly indurated, greenish, fine-grained sandstone containing a fauna similar to the Yorktown Formation of middle to upper Miocene age was found in place along the east wall of Lydonia Canyon (lat 40°23'00"N., long 67°38'30"W.) at a depth of 283 meters or 928 feet. This location is high on the continental slope, just beneath the edge of the Shelf. Similar sandstone with the same fauna has been dredged up as talus in two places along the east side of Hydrographer Canyon (lat 40°09'00"N., long 69°03'20"W., depth 319-410 meters or 1,319-538 feet), and in one place in Corsair Canyon (lat 40°21'20"N., long 66°08'20"W., depth 493-237 meters or 1,617-787 feet) (Stetson, 1949, p. 11, 33). The first two occurrences of Miocene talus are in the upper part of the continental slope, whereas the third is near the middle.

Stetson and Pratt (Uchupi, 1963, written commun.) dredged ten samples of semiconsolidated and consolidated Globigerina and Pteropod ooze from the top of the Blake Plateau. Four samples came from the area between lat 31°48'N. to 35°58'N. and long 77°18.5'W. to 77°34'W. in depths ranging from 639 to 828 meters (2,096 to 2,716 feet); six samples came from an area between lat 30°53.5'N. to 30°59.6'N. and long 78°13'W. to 78°47'W. in depths of 801 to 914 meters (2,427 to 3,089 feet). Three of these ten samples were found by Ruth Todd to contain foraminiferal assemblages that are either fossil or a mixture of fossil and Recent species. She tentatively classified these as Miocene. They are from lat 31°58'N., long 77°18.5'W. at a depth of 801 meters (2,427 feet); lat 31°48'N., long 77°35'W. at a depth of 639 meters (2,096 feet); and lat 30°58'N., long 78°31'W. at a depth of 810 meters (2,657 feet).

Three cores of Miocene rocks have come from the edge of the Blake Plateau. One from lat 28°35.5'N., long 77°10'W. at a depth of 1,005 meters (3,296 feet) contained a fauna ranging in age from late Miocene at the bottom to Recent at the top, through a thickness of only 443 cms. (Ericson, Ewing, Wollin, and Heezen, 1961, p. 235). Late Miocene Foraminifera were found in abundance from 443 to 220 cms. and only rarely from 200 to 130 cms. Pliocene and Pleistocene Foraminifera were found in the upper 130 cms. The core bore no evidence of slumping, so it is assumed that sedimentation from late Miocene time to Recent is represented in this 443 cm. core. Another core at lat 30°04'N., long 76°57'W. at a depth of 1,080 meters (3,542 feet) consisted of 660 cms. of Miocene chalk and 155 cms. of Pleistocene and Recent ooze (Ericson, Ewing, Wollin, and Heezen, 1961, p. 236). The third core from lat 30°23'N., long 76°35'W. at a depth of 1,865 meters (6,117 feet) was made up of 326 cms. of pyritic clay of Miocene age and 54 cms. of Globigerina and Pteropod ooze of Pleistocene and Recent age.

A single specimen of Miocene marl (Chipola Formation) has been reported by Bush (1951) from the sea bottom in the western part of the Straits of Florida, which connect the Atlantic Ocean and Caribbean Sea. It was accidently dredged from a depth of 686 meters (2,250 feet) at lat 24°10'N., long 81°31'W. Bush (ibid., p. 102) believes this specimen to have come from a submarine outcrop.

Neogene rocks:--Numerous samples recovered by Ericson, Ewing, Wollin, and Heezen (1961, p. 234-241) contained a mixed assemblage of Miocene and Pliocene microfossils. These rocks are thought most likely to be late Miocene in age, but are assigned the more inclusive Neogene age for lack of conclusive evidence. Four of these cores came from the Hudson Canyon near the base of the continental slope at depths of 3,330 to 3,820 meters (10,922 to 12,530 feet) and consisted of green marcasitic silt. Two cores from the escarpment of the Blake Plateau (lat 28°42'N., long 76°46'W., and lat 28°26'N., long 76°40'W.) at depths of 1,260 meters (4,133 feet) and 1,730 meters (5,674 feet) contained Neogene foraminiferal ooze beneath 70 to 105 cms. of Pleistocene foraminiferal sand. Three cores from the walls of Northeast and Northwest Providence Channels in the Bahamas found Neogene green marcasitic silt, hydrotroilite, and Globigerina ooze beneath 110 to 215 cms. of Pleistocene and Recent Globigerina ooze. The thin layers of ooze suggest very slow sediment accumulation on the lower continental slope since Miocene time.

Pliocene rocks:--Stetson (1936, p. 350; 1949, p. 12) dredged a friable very fine-grained greensand from depths of 640 to 512 meters (2,099-1,679 feet) up the east wall of Lydonia Canyon (lat 40°27'00"N., long 67°39'30"W.). According to Cushman (1936, p. 414), most of the species of Foraminifera in the greensand are similar to living species now confined to warmer southern waters, and seemingly indicate that they were deposited in late Tertiary time, before the northern Atlantic coastal waters were cooled by Pleistocene ice accumulations.

Tertiary or Quaternary bottom deposits

Late Pliocene or Pleistocene deposits:--Samples of hard green silt of either late Pliocene or Pleistocene age have been dredged by Stetson (1949, p. 13) from Oceanographer Canyon (lat 40°24'30"N., long 68°07'30"W.) at depths of 596-480 meters (2,055-1,574 feet); from Gilbert Canyon (lat 40°29'45"N., long 67°51'15"W.) at depths of 600-530 meters (1,968-1,738 feet), and from Lydonia Canyon (lat 40°27'00"N., long 67°39'00"W.) at depths of 640-512 meters (2,099-1,679 feet). Some Foraminifera in these samples had the same late Pliocene resemblances that were found in the greensand referred to the Pliocene, but the rest of the assemblage suggested a distinctly colder sea environment. In addition, there was a greater proportion of living species in the green silt than in the greensand. Cushman (1936), p. 414) expressed the opinion that the green silt, representing a cold environment, is younger than the greensand and it is therefore late Pliocene or Pleistocene in age. Ericson, Ewing, Wollin, and Heezen (1961, p. 234) thought it improbable that the green silts from canyons on Georges Bank were Pleistocene because the lithology and fauna differ strikingly from sediments of known Pleistocene age found elsewhere in the Atlantic. A similar green silt was cored by them near Hudson Canyon (lat 39°25'N., long 71°23'W.) at a depth of 1,400 meters (4,512 feet).

Quaternary bottom deposits

Pleistocene and Recent deposits:--Numerous samples of Pleistocene and Recent materials have been dredged by Stetson (1949, p. 15-21) from canyons ranging from Corsair Canyon on the north to Norfolk Canyon on the south (See pl. 2 and fig. 2). Phleger (in Stetson, 1949, p. 53) reported a subarctic foraminiferal fauna beneath the Recent temperate fauna and assigned a Wisconsin age to the lower sediments in the cores. Stetson (1949, p. 15) pointed out that the Wisconsin sediments consist mainly of clay and the finer grades of silt, and that these sediments are gray or pink while wet in contrast to the overlying Recent sediments, which are greenish while wet and consist mainly of the coarser grades of silt and very little clay.

Ericson, Ewing, Wollin, and Heezen (1961, p. 202-228) have presented much later information on the lithology, particle-size distribution, and areal distribution of Pleistocene and Recent sediments both in the Atlantic and Caribbean regions. They concluded from variations in the planktonic Foraminifera in 108 cores and by extrapolation of rates of sediment accumulation determined by 37 radiocarbon dates in 10 cores that the last period of climate comparable with the present ended about 60,000 years ago and that a faunal change caused by a warming climate, and probably corresponding to the beginning of postglacial time, began about 11,000 years ago.

In addition to the Pleistocene silts and clays found in cores, patches of Pleistocene gravel and boulders of glacial origin are present on the Shelf from Cape Hatteras northward to Nova Scotia (Uchupi, fig. 94.1, 1963). Shepard, Trefethen, and Cohee (1934), p. 294) reported that pebbles and granules of granite and gneiss predominate in the gravels on Georges Bank and that quartzite and felsite are common. They also noted many boulders with flat polished faces, and some with striations, from this area. Wigley (1961) made a detailed analysis of the bottom sediments of Georges Bank and presented maps showing well-sorted sands on much of the Bank and less well-sorted gravel in the channels and on the northern and eastern parts (figs. 2 and 8, p. 183). Presumably the gravel and most of the sand is Pleistocene in age. Schlee (1964) recently pointed out the possible economic value of another extensive gravel deposit off New Jersey, first noted by Shepard (1932, fig. 1, p. 1020).

Recent sediments have been the subject of intensive investigations sponsored by the U. S. Navy in the Tongue of the Ocean (see fig. 2) of the Bahama Islands (Marine Laboratory, University of Miami, 1958; Athearn, 1962A,B; Busby, 1962A,B,C). Some general conclusions about the composition and origin of these Recent sediments have been drawn by Busby (1962C, p. 64, 65) from these studies. The channel floor is covered by a relatively featureless, poorly sorted, unconsolidated ooze composed largely of tests of planktonic Foraminifera and pteropods, and reef detritus. The ooze, almost wholly calcium carbonate, consists mainly of silt-size particles; samples from the central reaches of the channel exhibit more sand than those from the sides. More than 50 percent of the sediment column sampled in the central and cul-de-sac areas of the Tongue of the Ocean gave evidence of turbidity current deposition, whereas samples from the flanks of the platform suggested that the sediment particles there accumulated directly from the overlying water. It appears that turbidity currents originate on the upper flanks of the platform, flow down gullies at relatively high velocities, and spread the load locally on the lower channel floor. Bottom ripple marks photographed at a depth of 1,000 fathoms suggest a bottom current of at least 0.3 to 0.7 knot.

The areal distribution of bottom sediments of Quaternary age on the continental margin off the eastern United States has been compiled on a map and discussed in a report by Uchupi (1963). The complete list of references dating from 1850 through 1962 attached to the report can be useful for anyone seeking more detailed information. Uchupi (p. C132) summarizes the areal distribution as follows:

"Relict glacial sediments blanket most of the continental shelf north of Hudson Canyon, and relict fluvial or nearshore quartzose sands occur throughout most of the shelf from Hudson Canyon to Cape Hatteras. Calcareous organic and authigenic sediments are the dominant sediment types on the continental margin farther south. Present-day detrital sediments are restricted to a narrow zone near shore, to the outer edge of the shelf off Long Island, and to the continental slope of Cape Hatteras. The predominance of relict and calcareous sediments indicates that present rate of deposition of detritus derived from land is very low over most of the continental shelf."

Offshore test holes

Eight test holes penetrating Tertiary rocks from 171 to 1,050 feet have been drilled and cored off Georgia and northeastern Florida. Two were drilled by the U. S. Coast Guard at one location (GA-88, plate 1) about 10 miles offshore from Savannah (McCollum and Herrick, 1964). Six were drilled under the JOIDES (Joint Oceanographic Institutions Deep Earth Sampling) program at locations (FL-117-122, plate 1) ranging from 27 to 221 miles offshore from Jacksonville and Cape Kennedy (JOIDES, 1965).

U. S. Coast Guard test holes off Savannah, Georgia

The U. S. Coast Guard test holes were drilled in 1962 on the Shelf in 54 feet of water at lat 31°56'53.5N., long 80°41'00"W. to determine physical properties significant in foundation design for a proposed light tower to replace the Savannah lightship. Seismic surveys prior to the test drilling indicated a north-trending linear zone of slight structural disturbance and possible faulting, according to consulting engineering reports referred to by McCollum and Herrick (1964) in a paper from which the information in this discussion has been extracted.

The oldest formation reached in this drilling was the Ocala Limestone of upper Eocene age. Comparison of the test holes with water wells on land reveals that rather uniform thicknesses of Oligocene, lower Miocene, and middle Miocene strata extend from shore seaward for at least ~~ten~~ 10 miles. However, both the upper Miocene rocks and the Pleistocene and Recent deposits decrease in thickness seaward, the most significant decrease being in the upper Miocene thickness, which ranges from about 145 feet inland to only 10 feet at the tower site. No facies changes were reported in the upper part of the Ocala Limestone or in the Miocene rocks, but it was noted that the Oligocene rocks, which consist predominantly of fossiliferous limestone inland and sandy limestone at the coast, grade seaward into a limy sandstone facies at the proposed tower site.

Structurally, the U. S. Coast Guard test holes appear to lie on a gentle upwarp parallel to a broad shallow syncline that plunges southward beneath the Coastal Plain as mapped on the lower Miocene limestone by McCollum and Counts (1964, plate 1). McCollum and Herrick (1964, p. C63) conclude that downwarping of the shallow syncline may have begun in the Oligocene or possibly even earlier, but that the principal downwarping occurred during the late Miocene.

JOIDES test holes off Jacksonville, Florida

The JOIDES_/ group with the participation of the U. S. Geological Survey conducted a shallow exploration program off northern Florida to ascertain the structure and stratigraphy of Cenozoic rocks beneath the Shelf, the Florida-Hatteras slope (as distinguished from the true Continental Slope beyond the Blake Plateau), and the Blake Plateau. Six test holes (FL-117-122, pl. 1) were drilled and cored in the alignment of a "Y" with the base about 27 miles offshore from Jacksonville, Florida, one extremity about 221 miles east of Brunswick, Georgia, and the other about 181 miles off Cape Kennedy (fig. 7). The test holes were drilled

Figure 7 near here

from the drilling vessel "Caldrill" to depths of 393 to 1,050 feet in water 15 to 648 fathoms deep. Two holes reached Paleocene rocks, three

_/ Joint Oceanographic Institutions Deep Earth Sampling program organized by Woods Hole Oceanographic Institution, Lamont Geological Observatory, the Institute of Marine Science of the University of Miami, and Scripps Institution of Oceanography.

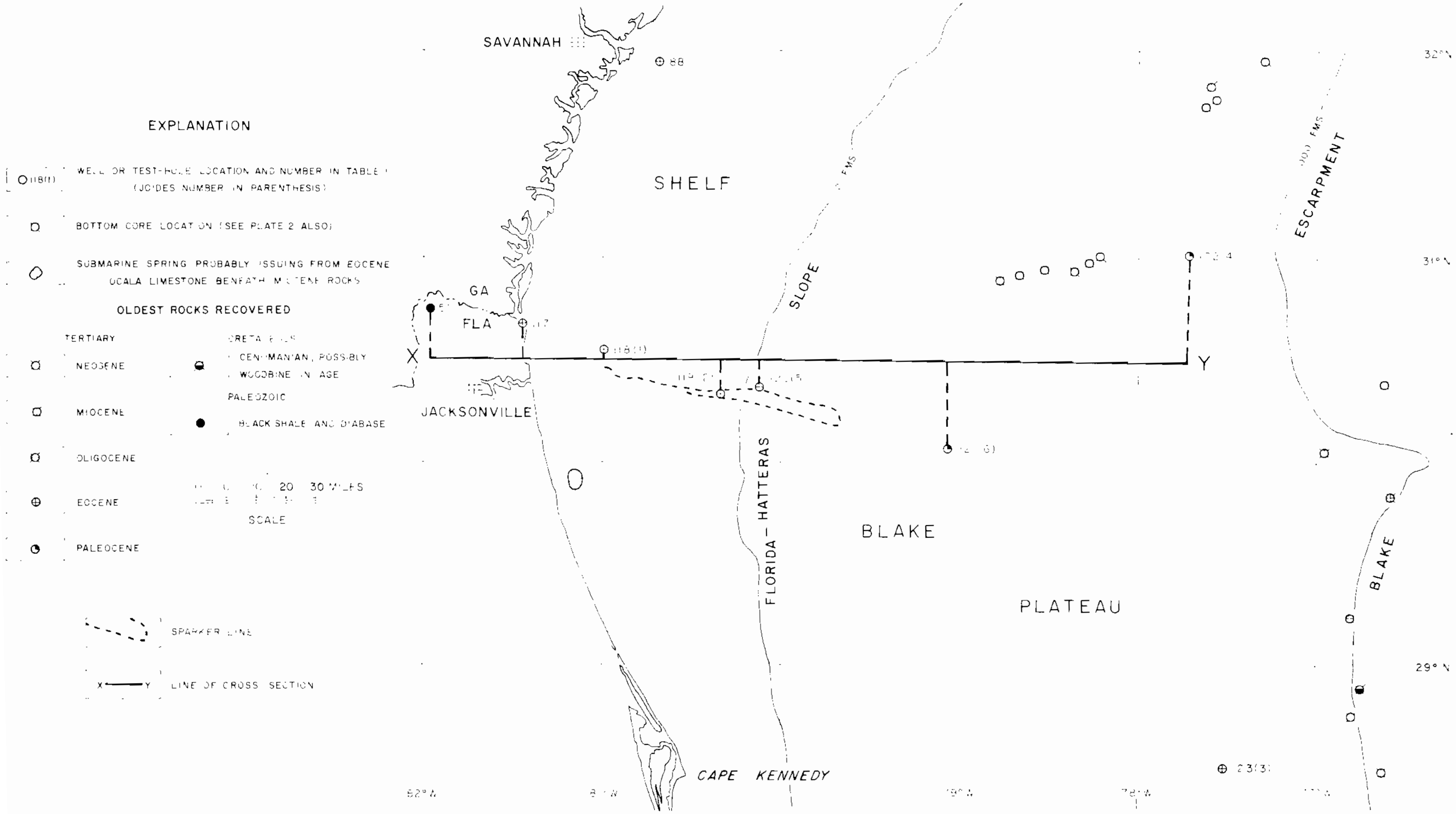

FIGURE 7. LOCATIONS OF JOIDES TEST HOLES, CROSS SECTION, AND SPARKER LINE OFF SOUTHEASTERN GEORGIA AND NORTHEASTERN FLORIDA

penetrated middle Eocene rocks, and one stopped in upper Eocene rocks. In addition to drilling the test holes, the group ran a sparker profile across the Shelf edge as indicated on figure 7. The stratigraphic correlations and structural implications of these investigations were reported in an article in Science (JOIDES, 1965) from which the basic data for the following cross section, profile, and discussion have been taken. Other sources of information about the JOIDES drilling program are Schlee and Gerard (1965) and Charm (1965).

Figure 8 is a cross section made by projecting the JOIDES stratigraphic data from the test holes to a 253-mile-long line normal to the sea coast at lat 30°30'N. (X-Y, fig. 7). This line is tied to two onshore wells, the St. Mary's River Corporation No. 1 Hilliard Turpentine Company well (FL-51) that reached Paleozoic rocks, and a Fernandino Beach water well (FL-117) that stopped in middle Eocene rocks. The large vertical exaggeration (1:251) necessary to show the stratigraphy along this cross section gives the impression of a steep slope or cliff at the edge of the Shelf, whereas this slope is relatively gentle, declining 10 to 13 fathoms (60 to 84 feet) a mile in the steepest part. Similarly, the structure beneath the Shelf is accentuated. The syncline along the Coast and the anticline beneath the Shelf are gentle warps with the steepest dips, found in the Eocene rocks, not exceeding 15 feet a mile. These gentle structures resemble the parallel warps along the Coast at Savannah, Georgia, as reported by McCollum and Counts (1964, pl. 1) and McCollum and Herrick (1964, p. C63).

Figure 8 near here

The test holes on this cross section and a bottom core (fig. 7) from the Blake escarpment indicate that Paleocene beds probably continue from the Coastal Plain to the edge of the Blake Plateau, but may be exposed as sea bottom along the lower part of the Florida-Hatteras slope. The Eocene, Oligocene, and Miocene beds appear to be prograded seaward beneath the outer Shelf and upper slope, absent from the lower slope, and greatly thinned on the Plateau. Bottom cores (fig. 7) show that Eocene and Oligocene strata crop out in the Blake escarpment and that Miocene and Neogene deposits blanket the outer Plateau and part of the escarpment. The absence of Eocene, Oligocene, Miocene, and post-Miocene deposits from the lower Florida-Hatteras slope corresponds rather closely to the axis of maximum velocity of the Gulf Stream.

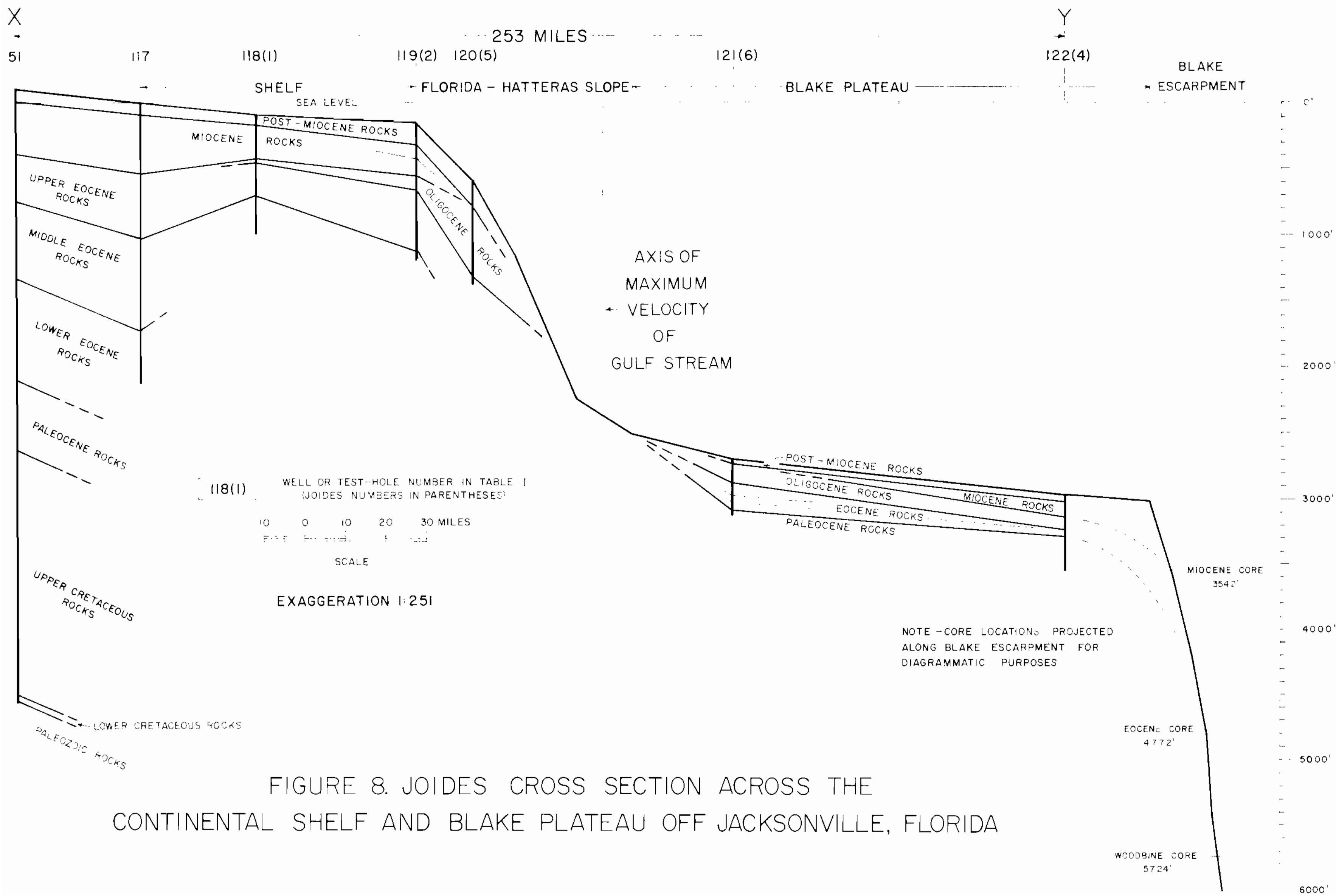

FIGURE 8. JOIDES CROSS SECTION ACROSS THE CONTINENTAL SHELF AND BLAKE PLATEAU OFF JACKSONVILLE, FLORIDA

Figure 9 is an interpretation of the JOIDES sparker profile across

Figure 9 near here

the Shelf and Florida-Hatteras slope as indicated in figure 7. The velocity interfaces have been related as closely as possible to the age assignments of rocks penetrated in test holes 1, 2, 5, and 6. In some instances, the correspondence is very good; in others it is poor. However, it is sufficient to give a general idea of the internal structure and depositional shapes of the Tertiary beds.

The most consistent reflecting bed seems to be the hard, dense, cherty, fine-grained limestone at the top of the Paleocene rocks in test hole 6 (see fig. 8). This reflector extends beneath the Shelf and Florida-Hatteras slope and appears to form the sea bottom at the base of the slope. Beyond this, it is covered by a thin deposit of younger rocks to the edge of the Blake Plateau, where bottom cores (fig. 7) indicate that Paleocene rocks crop out in the steep Blake escarpment. Small faults in Paleocene rocks are suggested by discontinuous reflections beneath the Shelf between test hole 1 and 2 (fig. 9).

Another fairly consistent reflecting surface is present at or near the top of the thick Eocene limestone sequence beneath the Shelf and slope. This reflector indicates that Eocene rocks thin down the slope and probably crop out at places along the lower part of the slope. Discontinuous internal reflections suggest that the Eocene deposits are prograded seaward beneath the slope.

Less consistent reflections outline the Oligocene and Miocene rocks. From these, it appears that the thickest Oligocene sequence is present beneath the slope near the Shelf break and that Oligocene rocks may crop out at places midway down the slope. The Miocene beds apparently terminate near the Shelf edge as they are not present in test hole 5.

As early as 1947, Pressler (1947) suggested a regional fault of unspecified age along the Shelf edge from Cape Hatteras to southernmost Florida, mainly on the basis of submarine topography. Recently Sheridan (1964, and ~~personal~~ written commun~~ication,~~ 1964) reported seismic evidence for a fault of late Eocene to early Miocene in age with a throw of 500 to 600 meters along the Shelf edge between lat 27°30' and 30°00'N. However, no major faults in Tertiary rocks at the Shelf edge are indicated by the JOIDES profile at approximately lat 30°20'N.

The JOIDES cross section (fig. 8) and sparker profile (fig. 9) indicate that the Shelf has been built seaward rather continuously during Tertiary time. Since Eocene time, the Shelf edge has been prograded about 9.3 miles by a mass of sediments 300 to 600 feet thick. Rates of deposition have been estimated (JOIDES, 1965, p. 715) for the Upper Eocene sequence as 1.6 cm/1,000 years on the Shelf and 0.3 cm/1,000 years on the Plateau.

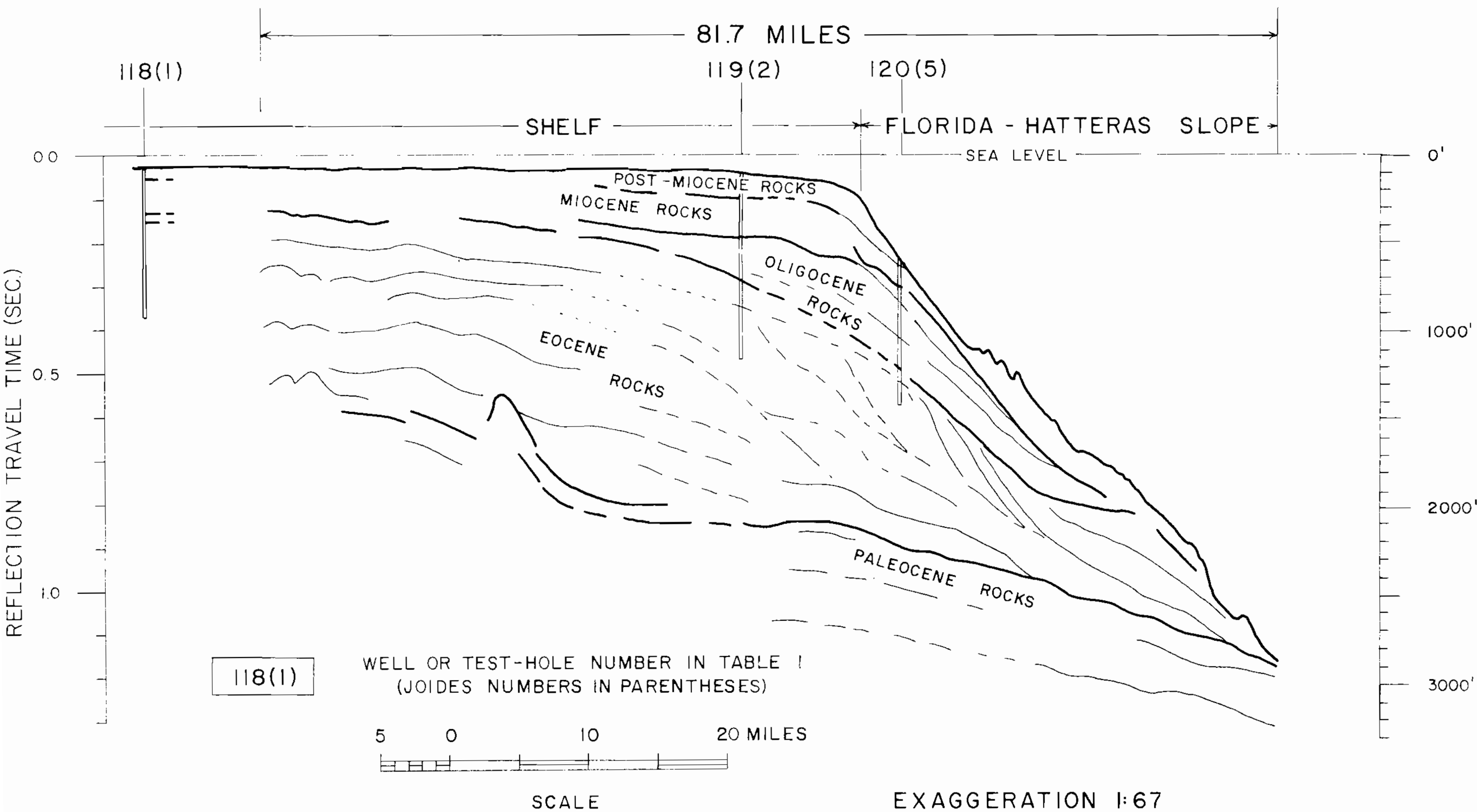

FIGURE 9. JOIDES SPARKER PROFILE

ACROSS THE CONTINENTAL SHELF OFF JACKSONVILLE, FLORIDA

The data revealed seem to support the theory that some time during early Tertiary time the Gulf Stream began flowing through the Straits of Florida, and the Stream's velocity prevented much sedimentation on the ancient shelf, except near the Coast (Shepard, 1959, p. 116-117). In addition, local scouring of the slope by bottom currents may have taken place (Heezen, Hollister, and Ruddiman, 1966). The ancient shelf of Cretaceous strata, which included the present Blake Plateau, subsided slowly along the Atlantic Coast, but was maintained by matching Cenozoic deposition except where the Gulf Stream swept the sediments away. This left a deep residual shelf now known as the Blake Plateau.

Regional correlations

A regional stratigraphic study such as this is necessarily based upon published reports to a large extent. Many of these cannot present detailed supporting data in the form of measured sections, sample logs, electric logs, and paleontology because of lack of space. So it is necessary not only to examine the published reports critically, but also to search out the supporting detail in records, files, and unpublished reports. These basic data may be supplemented with later information and then restudied.

About 400 wells in 11 states and three wells in the Bahama Islands and vicinity (table 1) were selected for their stratigraphic significance in this study. Drilling records of some sort are available for all these wells, but sample logs with some paleontology are available for less than half. Electric logs for about 200 wells, most of them in Florida and Georgia, were obtained and correlated. The regional cross sections of this report show 49 electric logs, 9 sample logs, and 2 drillers logs. For the sake of uniformity and simplicity, electric logs, rather than sample logs, have been shown on cross sections where available.

Both electric logs and sample logs are available for many of the deep wells along the coast. In general, the characteristics of rock units in the region are more distinctively and accurately recorded on the electric logs than on the available logs prepared from rotary samples by many different workers. Selectively, however, the sample logs and detailed paleontology of key wells provide the stratigraphic age assignments to which the electric log correlations must be reconciled. So the electric logs serve principally as objective records of relatively uniform value for selecting traceable rock-unit boundaries within paleontologic control, and for the tracing of these rock units through areas lacking substantial paleontologic and lithologic control.

Two approaches have been made to the correlation of the Mesozoic and Cenozoic rocks along the east coast: (1) from the Gulf Coast marine facies in Florida northward through deep wells at the coast line, and (2) from the outcrops at the Fall Line downdip through shallow wells to the same deep wells at the coast line. The first approach utilized the well-known and documented microfossil zones used in distinguishing both surface and subsurface rock units in the Gulf Coast region. The deep wells along the coast penetrate a greater proportion of marine rocks than those farther inland and, as a result, offer more paleontologic evidence and stratigraphic uniformity. The second approach from the outcrops to the deep wells attempts to relate local rock units and names to those carried northward from the Gulf Coast. Numerous difficulties are involved in this. The rocks exposed at the Fall Line are predominantly clastic and relatively nonfossiliferous in character, with many subdivisions and contacts based entirely upon lithology. These rocks thicken and change facies downdip so that many of the distinguishing features on which local outcrop names are based become indistinct in the deep wells. Fossils are not sufficiently abundant nor definitive enough to delimit the rock units in many of the shallow wells.

The technique employed in correlating the electric logs has been to plot all paleontologic data and reported tops of geologic units on the electric-log strips. The principal subdivisions of the rocks and bounding unconformities are drawn in key wells with paleontologic control. These are extended to adjacent wells by zoning the electric logs with both a number and a color code into the smallest traceable units within the larger units. This permits the recognition of the addition of new beds downdip and the absence of rocks at unconformities updip. In effect, it requires an accounting for all changes from well to well within the larger units controlled by paleontology. In doing this, no electric log correlations have been made knowingly in violation of available paleontologic data, although numerous changes of earlier opinions based on lithology have been suggested.

In general, the boundaries of most rock units shown on these cross sections are drawn within fossil control on lithology as reflected by electric-log characteristics. These boundaries are not subject to exact agreement among geologists. Difference of opinion as to the top and bottom of units within thick sequences of clastic or carbonate rocks may be expected in the magnitude of a hundred feet or more in some of the areas without indicating significant disagreement on the regional history. This difference often arises as a result of new nonfossiliferous beds appearing downdip that can equally well be placed in the overlying or the underlying rock unit on the basis of current information. As a region is more thoroughly explored by the drill, better agreement on correlations develops, partly on more conclusive evidence, but also as accepted communication practice in day-to-day operations.

The subsurface stratigraphy of the Mesozoic and Cenozoic rocks is outlined diagrammatically in this report by eight regional cross sections, whose traces are shown in figure 6. Cross section AB (pl. 9) follows the Atlantic coastline, carrying the Gulf Coast equivalents from the Florida Keys to Long Island. Cross sections CD, EF, GH, IJ, and KL (pls. 10, 11, 12, 13, and 14) attempt to tie these equivalents to the outcrops and local terminology in New Jersey, Maryland, North Carolina, and Georgia. Cross section MN (pl. 15) extends correlations across the Florida peninsula. Cross section OP (pl. 16) suggests correlations from the Florida Keys to Andros Island in the Bahamas and points out the possible relationship of stratigraphy to the sea bottom. The nomenclature used on these cross sections for subsurface rocks in different states is summarized in table 2.

Table 2 near here IN POCKET

Principal reliance has been placed on assemblages of Foraminifera for age assignments of lithologic units in wells on these cross sections. The age relationships of these assemblages were first worked out and used extensively in the Gulf Coast region, where several hundred thousand wells have been drilled in the search for petroleum. The most significant Foraminifera in the assemblages found in cores and samples from the wells on the cross sections are listed in Table 3 (In pocket) prepared by E. R. Applin. Hundreds of additional microfossil identifications and many detailed lithologic descriptions for these wells and nearby wells have been available from not only the published sources noted on each cross section but also from unpublished sources such as the files and collections of P. L. and E. R. Applin, state geological surveys, and some oil companies. Publication of complete fossil lists and lithologic descriptions for wells in this huge province is beyond the scope of this report.

Mesozoic rocks

Triassic(?) rocks

Triassic rocks, which consist of red arkose, sandstone, shale, tuff, and basalt flows, in places intruded by diabase, are present in down-faulted basins in the basement rocks of the piedmont. Similar Triassic-filled basins are thought to exist beneath the Coastal Plain on the basis of well and seismic data (Bonini and Woollard, 1960, p. 304, 305; Tectonic map of the United States, U. S. Geol. Survey and American Assoc. Petroleum Geologists, 1962), although the existence of one postulated on seismic velocities alone at Fayetteville, North Carolina, seems to be in doubt (Bonini, 1964, p. 102; Schipf, 1964, p. 721-723). Rocks lithologically similar to the exposed Triassic rocks have been penetrated by several wells on these cross sections and are referred to as Triassic(?).

Well GA-61 (Mont Warren No. 1 Chandler) and well GA-72 (Stanolind Oil and Gas Co. No. 1 Pullen) in southwestern Georgia, shown on cross section KL (pl. 13), penetrated more than 900 feet of red and green shale and sandstone beds, with some diabase sills in well GA-72 that are generally regarded as representative of Triassic sequences. Well AL-3 (W. B. Hinton No. 1 Creel) in southeastern Alabama about 40 miles updip from well GA-61, penetrated a 700-foot thick sequence of basic igneous sills interspersed with thin clastic beds beneath Lower Cretaceous rocks. This dominantly igneous sequence may be Triassic(?) in age also, although the lithology is less distinctive.

Rocks assigned to the Triassic(?) are present also in the subsurface of Maryland along the line of cross section EF (pl. 11). Well MD-6 (Washington Gas Light Co. No. 3 Mudd) near the Fall Line is reported (Ball and Winer, 1958) to have penetrated 237 feet of Triassic clastic beds beneath the Lower Cretaceous Patuxent Formation. The presence of these rocks close to the Fall Line suggests that they may be preserved in a graben-like feature similar to those downfaulted Triassic blocks more or less on strike in the piedmont of Virginia.

Well MD-12 (The Ohio Oil Co. No. 1 Hammond), well MD-13 (Socony Vacuum Oil Co. No. 1 Bethards), and well MD-14 (Standard Oil Co. of New Jersey No. 1 Maryland Esso) near the coastline on cross section EF (pl. 10) penetrated rock sequences, 165 to 525 feet thick, that were assigned to the Triassic by Spangler (1950, p. 121). Anderson (1948, p. 100) regarded the same sequences in well MD-12 and MD-13 as Triassic, and the sequence in well MD-14 as Lower Cretaceous Patuxent on the basis of differing hardness and color. This unit in wells MD-12 and MD-13 consists of beds of hard, dark gray shale and sandy shale with maroon mottling, quartz conglomerate with some white feldspars, and hard reddish-brown and green shale, sandy shale, and arkosic sandstone. In well MD-14 farther downdip, the sequence consists of beds of coarse-grained sandstone containing pebbles, gravel, and kaolinized feldspars, beds of gray, green, and brown shale, and some calcareous layers.

The lithologies and electric-log curves for these nonfossiliferous sequences are not dissimilar enough to rule out the possibility that these sequences may be correlative facies. If so, they could be either Triassic(?) or equivalent to the Upper Jurassic or Lower Cretaceous (Neocomian) rocks in the Cape Hatteras well NC-14 (pls. 9 and 12). For these reasons, the broad, relatively noncommittal term "Mesozoic rocks of uncertain age, possibly Neocomian" is used on both plates 9 and 11.

Upper Jurassic or Lower Cretaceous (Neocomian) rocks

Rocks of Late Jurassic or Early Cretaceous (Neocomian) age, which do not crop out in eastern North America, are present beneath southern Florida, where they have been partially penetrated by deep wells. Applin and Applin (1965, p. 18-25) have described these rocks in the Amerada Petroleum Corp. No. 2 Cowles Magazine well in St. Lucie County, and have named the sequence the Fort Pierce Formation for a nearby city. The type sequence in this well is 2,220 feet thick and consists of a lower red clastic unit, 170 feet thick, that rests on highly altered igneous basement rock, and an upper carbonate unit, 2,050 feet thick. The upper carbonate unit is made up of alternating finely crystalline, partly oolitic and bioclastic limestone, dolomitic limestone, and dolomite beds interspersed with thin gray shale and anhydrite beds. The characterizing faunal assemblage of the Fort Pierce Formation contains fossils that are, in part, Late Jurassic and, in part, Early Cretaceous in age. The distinctive features of the microfaunal assemblage have been illustrated by Applin and Applin (1965, pls. 3, 4), although the definitive species could not be described from thin sections. The fauna is characterized, mainly, by abundant specimens of Foraminifera belonging to the family Ataxophragmiidae, sub-family Verneuilininae, that are small and biserial throughout the larger part of their development. A large conical species of *Cuneolina*(?) is another definitive fossil, and several undescribed species of *Pseudophragmina* are moderately common. The *Cuneolina*-like form is known, also, in subsurface beds of equivalent age in Israel.

The Fort Pierce Formation has been penetrated by wells FL-104, FL-86, FL-111, and FL-109 on cross sections AB and OP (pls. 9 and 16). The deepest penetration (1,115 feet) was made by well FL-109 (Gulf Oil Corp. No. 1 State Lease 373) on Big Pine Key (pl. 16). The formation wedges out northward along cross section AB and is absent from well FL-73 (Humble Oil and Refining Co. No. 1 Carroll) in Osceola County, Florida, where rocks of Trinity age rest upon biotite granite of pre-Mesozoic age.

Rocks of Upper Jurassic and Lower Cretaceous (Neocomian) age are also present in well NC-14 (Standard Oil Co. of New Jersey No. 1 Hatteras Light) on cross section GH (pl. 12) in North Carolina. There the sequence, 8,960 to 9,878 feet in depth, grades downward from finely crystalline, partly oolitic limestone and gray shale beds to red and green sandy shale layers and red-stained, fine-to-coarse-grained sandstone beds, partly conglomeratic and arkosic, at the base. The lower red clastic beds may correspond roughly to those noted by the Applins in the Amerada Petroleum Corp. No. 1 Cowles Magazine well in Florida. Swain (1947, p. 2058) assigned the beds between 9,150 and 9,878 feet to pre-Trinity (Coahuila?) in 1947. Later, in 1952, he considered the beds from 8,500 to 9,878 feet as Upper Jurassic(?) and referred to them as "beds of Schuler(?) age" (Swain, 1952, p. 66). E. R. Applin reports molds of *Atopochara* sp., suggestive of early Trinity age, between 8,505 and 8,515 feet, and *Anchispirocyclina henbesti* Jordan and Applin in a core at the depth of 9,115-9,116 feet. Maync (1959, p. 66) considered the latter fossil to be closely similar to *Iberina lusitanica* (Egger) that in Europe "straddles the Jurassic-Lower Cretaceous boundary." It is possible that *Anchispirocyclina henbesti* is also indicative of beds of Late Jurassic or Early Cretaceous age. Therefore the base of rocks of Trinity(?) age may be at 8,800 feet, where it is drawn tentatively in this report, or as deep as 8,960 feet.

The sequence of rocks termed "Mesozoic rocks of uncertain age, possibly Neocomian" in well MD-14 on cross section AB (pl. 9) may be equivalent to the Upper Jurassic or Lower Cretaceous (Neocomian) in well NC-14 at Cape Hatteras. The same rocks probably are represented in the lower part of the interval marked "rocks of Trinity(?) age and older" in well NJ-25 (Anchor Gas Co. No. 1 Dickinson) in New Jersey and wedge out updip between that well and well NJ-26 (U. S. Geological Survey No. 1 Island Beach). As pointed out in the discussion of Triassic(?) rocks, the relation of the hard, reddish clastic sequence resting on basement in wells MD-12 and MD-13 on cross section EF (pl. 11) to the lower, soft gray clastic beds in well NC-14 is in doubt.

Lower Cretaceous rocks

The Cretaceous system in the Gulf Coast region is divided into the Comanche Series and the Gulf Series. The Comanche Series is subdivided into the Trinity, Fredericksburg, and Washita Groups. The lower two groups are entirely Early Cretaceous in age, but the Washita Group is regarded as mostly Early Cretaceous but partly Late Cretaceous in age by the U. S. Geological Survey (Imlay, 1944) on the basis of world-wide fossil zones. The boundary between Lower and Upper Cretaceous rocks on these cross sections is indefinite because of lack of paleontologic detail and is shown diagrammatically with a query. The top of rocks of Washita age can be readily identified within a few tens of feet in most sets of drill cuttings. In discussion of distribution of Lower Cretaceous rocks in this report, all rocks of Washita age are grouped with those of Trinity and Fredericksburg age.

Rocks of Lower Cretaceous age, several hundred feet of sandstone and shale beds, are recognized at the surface in part of the Salisbury embayment, as shown by the Geologic map of the United States (Stose, 1932). They may be represented at or near the surface in northern North Carolina, western Georgia, and Alabama by thin clastic beds inseparable lithologically from the basal Upper Cretaceous beds. Lower Cretaceous beds dip seaward from the Fall Line at rates that increase from about 15 feet a mile to more than 60 feet a mile (pl. 11). The thickness and marine constituents increase accordingly.

In southern Florida, the Lower Cretaceous rocks are dominantly carbonates and exceed 6,700 feet in thickness in the Florida Keys (well FL-109, pl. ~~15~~ 16). Northward along cross section AB (pl. ~~8~~ 9), the rocks wedge out on the Peninsular arch, then reappear as a thin clastic unit across parts of Georgia and South Carolina. They are missing from the higher parts of the Cape Fear arch in North Carolina but are present on the east flank as a thickening wedge of mixed clastic and carbonate rocks more than 2,800 feet thick at Cape Hatteras (well NC-14) as correlated on Foraminifera by E. R. Applin (written commun. to J. Reeside, 1957), and 2,600 feet thick in Maryland (well MD-14). Lower Cretaceous rocks probably extend into northern New Jersey but do not reach Long Island.

Considerable thicknesses of Lower Cretaceous rocks are present in southwestern Georgia. Cross section KL (pl. ~~13~~ 14) shows more than 2,500 feet of dominantly clastic, undifferentiated, Lower Cretaceous beds in wells GA-61 and GA-72.

The Lower Cretaceous is subdivided on these cross sections only in Florida, North Carolina, and Maryland, and in one well in New Jersey where the rocks are sufficiently thick, uniform, and fossiliferous to provide fairly reliable unit correlations. These subdivisions and their correlations from well to well are most reliable in the southern Florida carbonate section and least reliable in the mixed clastic and carbonate section in Maryland and New Jersey. Little fossil evidence suitable for subdividing the Lower Cretaceous rocks exists north of Cape Fear, and the dashed correlation lines on the cross sections represent an opinion based mainly on lithology and electric log data available in 1965.

9.1267

The regional distribution of Lower Cretaceous rocks and the underlying rocks classed as Upper Jurassic or Lower Cretaceous (Neocomian) in age in this report is outlined on plate ~~16~~ 17. These rocks are present at or near the Fall Line in New Jersey, Maryland, Virginia, northern North Carolina, western Georgia, and Alabama, but are absent beneath most of the Coastal Plain in southern North Carolina, South Carolina, and eastern Georgia, and on the crest of the Peninsular arch in northern Florida. Thicknesses of about 3,000 feet at Cape Hatteras and about 6,000 feet in the Florida panhandle and Keys are present beneath the Coastal Plain. Thick sequences are probably present also offshore on the Atlantic Continental Shelf, where geologic data are lacking and seismic data too sparse and contradictory to permit representation of thicknesses on plate 16. Form lines are used to suggest depositional shapes, and minimum estimates of maximum thicknesses are shown for general use in exploration planning. It seems probable that thicknesses may exceed, perhaps considerably, 5,000 feet in the Southeast Georgia embayment, 5,000 feet in the Baltimore Canyon trough, and 3,000 feet in the Georges Bank trough, judging by the rate of thickening onshore and the scattered seismic profiles offshore (pl. 5).

Rocks of Trinity age

Rocks of Trinity age along cross sections AB and OP (pls. 9 and 16) have a maximum thickness of 3,030 feet in well FL-111 (Gulf Oil Corp. No. 1 SFL 826-Y) at the western end of the Florida Keys, where they are principally anhydrite, limestone, and dolomite. The thickness decreases northeastward to 2,200 feet in well FL-104 (Sinclair Oil and Gas Co. No. 1 Williams) on Key Largo, and continues to decrease northward along cross section AB (pl. 9) to a wedge edge of clastic rocks against the Peninsular arch (well FL-57). Rocks of Trinity age are absent from wells on cross section AB (pl. 9) in northern Florida, Georgia, and South Carolina.

A sequence of mostly sandstone, siltstone, and shale beds in well NC-14 at Cape Hatteras, North Carolina, and in wells MD-12, MD-13, and MD-14 in Maryland (pls. 9, 11 and 12), has been assigned an age of Trinity(?). This sequence is at least 1,150 feet thick, and may be as much as 1,455 feet thick if the overlying beds of Trinity(?) or Fredericksburg(?) age are included. It is present in well NJ-25 (Anchor Gas Co. No. 1 Dickinson) at Cape May, New Jersey, but has not been differentiated from underlying sedimentary rocks of Mesozoic age. In well NJ-26 at Island Beach farther north in New Jersey, rocks of Lower Cretaceous age are thought to be about 518 feet thick, but no fossil evidence was reported from these beds and no subdivisions are apparent.

Many specimens of *Atopochara trivolvis* Peck were found at 8,505 feet in well NC-14, and at 4,430 feet in well NJ-25, indicating the presence of beds of early Cretaceous age in these wells. R. E. Peck, who checked the specific determination of these fossils, stated (1957, p. 21) that "*Atopochara trivolvis* is widely distributed in the Lower Cretaceous Aptian non-marine deposits of the Gulf Coast and Rocky Mountain regions," and he (p. 21) considered it "an excellent guide fossil." In the Hatteras Light well (NC-14), *Choffatella decipiens* Schlumberger is present about 400 feet below the highest occurrence of *A. trivolvis*.

Another type of microfossil, the megaspore *Arcellites disconformis* (Miner) Ellis and Tschudy (Ellis and Tschudy, 1964, p. 75) was identified by R. H. Tschudy in a sample of cuttings at 4,400-4,410 feet in the Anchor Gas Co. No. 1 Dickinson well. In his analysis of the sample, Tschudy (written commun., April 30, 1964) stated that "*Arcellites disconformis* is found in Lower Cretaceous samples. In eastern United States it has been found only in the Patuxent Formation. I am fairly confident of a pre-Albian, Early Cretaceous age determination..." Tschudy listed a number of other plant fossils in the sample and stated, "The absence of any Angiosperm pollen suggests pre-Albian."

Rocks of early Trinity age

In Florida, rocks of Trinity age have been divided by Applin and Applin (1965, p. 36, 45) into rocks of early and late Trinity age within which two formational units have been defined. The rocks of early Trinity age are about 1,500 to 2,100 feet thick in wells along the Florida Keys (pl. 16). At the west end of the Keys (well FL-111), the 1,589-foot interval is composed primarily of thick anhydrite beds containing some lenses of salt. This evaporite facies has been termed the Punta Gorda anhydrite (Applin and Applin, 1965, p. 39). Eastward along the Keys, the evaporite facies continues to mark the top of rocks of early Trinity age, but gives way to thick oolitic limestone and dolomite beds and thin dark shale layers in the lower half (see well FL-104, pl. 16). The Punta Gorda anhydrite is 783 feet thick in well FL-104, on Key Largo; no anhydrite was penetrated in well BA-2 on Andros Island in the Bahamas. Evaporite beds have been reported in well BA-1 drilled to a depth of 18,906 feet on Cay Sal (pl. 1 and fig. 3), but no samples have been available to confirm this or to suggest any correlations. However, known thicknesses do suggest that a sizeable evaporite basin existed in Early Cretaceous time to the south and southwest of Florida. Northward from Key Largo along cross section AB (pl. 9), the rocks of early Trinity age grade from the evaporite and carbonate facies (well FL-104) into nearshore marine and continental clastic facies (wells FL-73 and FL-57), and wedge out against the Peninsular arch.

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Rocks of early Trinity age in well FL-104 (Sinclair Oil and Gas Co. No. 1 Williams) on Key Largo are reported to have yielded two specimens of the ammonite Dufrenoya texana Burckhardt in a core taken about 120 feet above the top of the Fort Pierce Formation (Applin and Applin, 1965, p. 45). D. texana is a diagnostic fossil of the outcropping Cow Creek Limestone of early Trinity age in central Texas (Adkins, 1928, p. 252-253), and of the stratigraphically equivalent Pine Island Shale Member of the Pearsall Formation (Trinity) in the subsurface of the Coastal Plain in Texas, Louisiana, and Arkansas (Imlay, 1944).

Choffatella decipiens Schlumberger also is a characterizing fossil in the marine beds of early Trinity age in southern Florida, and in this area one or more fossiliferous lenses generally contain many specimens. C. decipiens has a world-wide distribution, and Maync (1949, p. 535) records its stratigraphic range as "from the earliest Cretaceous to somewhere in the Albian." It is present at depths of 11,200, 11,580, and 12,259 feet in well FL-86 (Humble Oil and Refining Co. No. 1 Tucson) and in several other wells in the southern part of the Florida peninsula.

Orbitolina texana (Roemer) is usually well represented in beds of early Trinity age in southern Florida. The stratigraphic range of this species in Florida and in the western Gulf Coast is well described by Douglass (1960d, p. 6, fig. 2). Specimens were found at depths of 13,400 and 13,510 feet in well FL-109 (Gulf Oil Corp. No. 1 State of Florida) on Big Pine Key.

Rocks of late Trinity age

Rocks of late Trinity age in Florida, as defined by Applin and Applin (1965, p. 46), range from 1,441 to 713 feet thick west to east along cross section OP (pl. 16) in the Florida Keys. They wedge out northward on the peninsula between wells FL-86 and FL-73 on cross section AB (pl. 9). These rocks consist of a lower unit of limestone, dolomite, and shale beds termed the Sunniland Limestone (Pressler, 1947, p. 1859, and fig. 3; Applin and Applin, 1960, p. B-209) and an upper, unnamed unit composed of a thick anhydrite bed overlain by interbedded limestone, dolomite, and shale.

The Sunniland Limestone, which is the oil reservoir in the three oil fields of southern Florida, is 496 feet thick in well FL-111 at the west end of the Florida Keys (cross section OP, pl. 16). It decreases in thickness northeastward along the Keys and northward up the peninsula. At most places it consists of dark, fine-grained argillaceous limestone and light-tan chalky limestone interbedded with lenses of brown, granular dolomite and dark-gray shale. Lenses of bioclastic limestone and porous algal limestones are interspersed in the unit. Many lenses contain closely packed specimens of Dictyoconus floridanus Cole accompanied by many specimens of Orbitolina texana. Numerous specimens of both fossils are reported from wells FL-86, FL-104, FL-109, and FL-111 in table 3. Dictyoconus floridanus was formerly called Coskinolina sunnilandensis Maync, and its occurrence in Florida was believed to be restricted to the Sunniland Limestone. However, according to Douglass (1960b, p. 258), this species, though widely distributed in the Comanche rocks in the

Gulf Coast, is conspecific with Dictyconus floridanus, a species common in and described from the Avon Park, middle Eocene rocks in Florida. The available data indicate that after its widespread Comanche occurrence, the species disappeared for several million years, but returned to again become a characterizing fossil in the upper middle Eocene of Florida.

The upper, unnamed unit overlying the Sunniland Limestone is 988 feet thick at the western end of the Florida Keys (well FL-111, pl. 16), but decreases northeastward to less than 500 feet at Key Largo (well FL-104) and then wedges out northward up the peninsula between wells FL-86 and FL-73 as shown on cross section AB (pl. 9). Directly overlying the Sunniland Limestone is a sequence of interbedded anhydrite and argillaceous limestone that has been termed the "upper massive anhydrite" by oil geologists. It ranges from about 30 feet to 200 feet in thickness in southern Florida. Above the "upper massive anhydrite" are dark-to-light-tan, fine-grained-to-chalky limestones, lenses of granular dolomite, and dark shale beds. Some anhydrite layers are interbedded with the carbonates in the southern wells, and oolitic limestones are present in wells on the southwest flank of the Peninsular arch.

Specimens of *Orbitolina* that are generally referred to *Orbitolina minuta* Douglass are commonly found near the top of the beds of late Trinity age, and also at one or more lower levels within the unnamed post-Sunniland unit. The specimens are not abundant, but are helpful in defining the upper and lower boundaries of the post-Sunniland beds of Trinity age. Specimens have been identified from wells FL-86, FL-104, and FL-109 on the cross sections (table 3).

Rocks of Fredericksburg age

Rocks of Fredericksburg age are present beneath southern Florida and have been tentatively identified in wells in North Carolina and New Jersey (pl. 9). In southernmost Florida, the unit is composed mainly of dark-colored, fine-grained limestone and finely granular dolomite beds overlain by light-colored, chalky limestone beds. Bioclastic limestone beds, lenses of oolitic limestone, and some anhydrite layers are also included. Numerous oil stains and tarry residues have been reported mostly in the upper part of the rocks of Fredericksburg age by Applin and Applin (1965, p. 59). The thickness of the unit ranges from 1,850 feet in well FL-111 at the western end of the Keys to its termination as a clastic wedge on the flank of the Peninsular arch (wells FL-57 and FL-52, pl. 9).

The beds of Fredericksburg age in southern Florida generally contain abundant specimens of *Coskinolinoides texanus* Keijzer. This species, which was described from the Walnut Clay (Fredericksburg) of Texas, is believed to be stratigraphically restricted to the Fredericksburg Group. Specimens are reported from wells FL-86, FL-104, FL-109, and FL-111 in table 3. *Lituola subgoodlandensis* (Vanderpool) is also restricted to the Fredericksburg in its recorded upward range, and is generally found near the top of the beds of Fredericksburg age in the Florida peninsula. However, specimens of the species also occur at several lower levels within the group. *L. subgoodlandensis* is generally found some distance above the highest occurrence of *C. texanus*, and has a wider areal distribution in Florida than *C. texanus*. Specimens are reported in table 3 from wells FL-57, FL-73, and FL-86.

Rocks tentatively assigned a Fredericksburg(?) age in wells in North Carolina and Maryland are 415 to 660 feet thick (pls. 9 and 11) and consist principally of sandstone and shale beds with some thin limestone and limy shale beds interspersed in the Cape Hatteras well (NC-14). About 300 feet of lithologically similar and unfossiliferous beds that overlie rocks assigned a Trinity(?) age may be either Trinity(?) or Fredericksburg(?) in age and are so indicated on the cross sections (pls. 9, 11, and 12) of this report. Specimens of Lituola subgoodlandensis (Vanderpool), known only from rocks of Fredericksburg age or older and generally present in the upper part of rocks of Fredericksburg age in Florida, were found by E. R. Applin at a depth of 6,770 feet in well NC-14 at Cape Hatteras. Little fossil evidence suitable for separating these rocks from those of Trinity(?) and Washita(?) age is available in this region, and the correlations suggested by lithologic and electric-log characteristics are highly uncertain.

Rocks of Washita age

Rocks of Washita age range from 1,987 to 1,380 feet in thickness in wells on cross section OP (pl. 16) along the Florida Keys and wedge out northward against the Peninsular arch as shown on cross section AB (pl. 9). The lithology is dominantly very fine grained calcitic dolomite containing chalky limestone and anhydrite layers in the upper part in some wells. The evaporite constituents are thicker and more numerous in the southernmost wells in Florida. Traces of glauconite are present in the beds penetrated in wells on the flank of the Peninsular arch. Oil stains and tarry residues have been reported from both limestone and dolomites of Washita age in wells scattered over southern Florida (Applin and Applin, 1965, p. 63).

Nummoloculina heimi Bonet is the key fossil of beds of Washita age in the Florida peninsula. The Nummoloculina limestone at the top of the beds of Washita age is composed chiefly of large specimens of this fossil and the species is abundant at many lower levels within the unit. The fauna of the beds of Washita age in Florida is strikingly similar to that of the upper part of the El Abra Limestone of Mexico, and to the top foot of the Devils River Limestone (Georgetown) of Texas (Conkin and Conkin, 1956, fig. 3). Muir (1936, p. 41) reported "Pecten roemeri Hill was identified by L. W. Stephenson in limestone fragments blown from the Mexican Gulf Oil Company wells No. 3 Tepetate and No. 23 Zacamixtle *** The horizon at which the oil was found in these two wells can be referred to the top or close to the top of El Abra Limestone. P. roemeri is a diagnostic fossil for the top of the 'Buda' limestone of Texas." N. heimi is found in older units of the Comanche rocks, but its size and abundance in the beds of Washita age in southern Florida make it a dependable guide fossil for the late Comanche rocks in that area. Specimens have been found by E. R. Applin in wells FL-57, FL-73, FL-86, FL-104, FL-109, and FL-111 (table 3).

North of the Cape Fear arch, a sequence of rocks 320 to 600 feet thick in wells on cross sections AB, EF, and GH (pls. 8, 10, and 11) has been tentatively assigned a Washita(?) age. It consists mainly of thick beds of dark-gray sandy-to-limy shale and fine-grained sandstone with a few thin layers of lignite in wells farthest inland, and grades seaward into thinner-bedded alternations of sandstone, gray limy shale, and limestone in the upper two-thirds, and thick beds of siltstone, sandstone, and shale in the lower one-third (well NC-14). Rocks of Washita(?) age are not differentiated from underlying rocks northward into New Jersey and New York. Southward, they seem to extend high up the flank of the Cape Fear arch, overlapping older Lower Cretaceous rocks to rest on pre-Mesozoic igneous and metamorphic rocks. Correlations in this area are relatively uncertain, as few definitive fossils have been reported in any of the wells drilled to date.

Upper Cretaceous rocks

Upper Cretaceous rocks of the Gulf Coast region include, in ascending order, the upper part of the Washita Group of the Comanche Series, and the Woodbine, Eagle Ford, Austin, Taylor, and Navarro Groups of the Gulf Series. The equivalents of these groups are shown on the cross sections; their distribution along the Atlantic Coast is discussed briefly. All rocks of Washita age are excluded from the discussion of Upper Cretaceous rocks because the paleontologic boundary drawn within the Washita Group cannot be identified in the drill cuttings.

Rocks of Upper Cretaceous age crop out almost continuously along the Fall Line from Alabama to North Carolina and from Maryland to Long Island. Upper Cretaceous rocks bordering the piedmont of northeastern North Carolina and Virginia are concealed by overlapping Tertiary deposits. The surface exposures, which range in thickness from a few hundred to more than 2,000 feet, are largely nearshore marine and continental clastics.

Submarine outcrops of Upper Cretaceous age are known in canyons along Georges Bank and in the lower part of the Blake escarpment (pl. 2) and may be present over considerable distances along the remainder of the continental slope. Cobbles of Cretaceous chalk have been found in the floor of Northeast Providence channel, 11,096 feet beneath the sea between the Bahama Islands. In the nearby Andros Island well (BA-2), Upper Cretaceous rocks were identified between depths of 8,220 and 10,760 feet. This suggests that Upper Cretaceous beds are exposed in the canyon walls which connect with the Blake escarpment on the continental slope. Reworked Cretaceous Foraminifera identified in a bottom core at a depth of about 15,000 feet on the continental rise, 155 miles southwest of Cape Hatteras, also indicate a good possibility that Upper Cretaceous outcrops are present along the continental slope near Cape Hatteras. The Hatteras Light well (NC-14), only 22 miles inland from the slope, penetrated Upper Cretaceous beds between depths of 3,033 and 6,100 feet. Assuming a regional dip of no less than 50 feet a mile as is common for Upper Cretaceous beds beneath the outer Coastal Plain, Upper Cretaceous strata might be expected to crop out or be thinly mantled by Cenozoic deposits between 650 and 1,550 fathoms, and possibly deeper. No test holes on the Shelf or Blake Plateau have reached Upper Cretaceous rocks.

Upper Cretaceous rocks, 1,235 to 3,067 feet thick, in wells along the line of cross section AB (pl. 9) are predominantly marine carbonates and clastics. In Florida, they are almost entirely marine carbonates and range in thickness from about 2,900 feet in the Florida Keys to less than 1,250 feet on the Peninsular arch (well FL-52, pl. 9). In wells along the coast of Georgia and South Carolina, the rocks are mixed marine carbonates and clastics about 2,000 feet thick. They are only 1,286 feet thick in well NC-58 on the Cape Fear arch, but northward range from 3,000 feet in thickness in well NC-14 at Cape Hatteras, North Carolina, to 1,800 feet in well NY-6 on Long Island. The percentage of clastics is higher in wells in Maryland, New Jersey, and Long Island than in the Cape Hatteras well. This is due in part to the fact that the Cape Hatteras well is considerably farther down the regional dip than the other wells.

The Upper Cretaceous rocks in southern Florida, where they consist of a thick succession of similar carbonate beds, are not subdivided on cross sections AB and OP (Pls. 9 and 16). They are subdivided in central Florida on cross sections AB and MN (Pls. 9 and 16), and northward on the remainder of the cross sections.

The regional thickness and distribution of Upper Cretaceous rocks of Gulf age in the Atlantic Coastal Plain is outlined on plate 18. These rocks are present at or near the Fall Line from Alabama to New York and dip seaward in much of the region at rates increasing from 10 feet a mile near the outcrop to more than 30 feet a mile at the coast (pls. 11 and 12). The thickness increases accordingly, reaching an onshore maximum of about 3,000 feet at Cape Hatteras and along the southern coast of Florida, as shown on plate 18. Form lines on plate 18 suggest minimum thicknesses to be expected offshore, not total thicknesses. Such form lines have a general or directional usefulness in selecting or comparing large areas for exploration but are not suitable for local predictions. Thicknesses considerably in excess of 3,000 feet may be present offshore in the Baltimore Canyon trough and the Southeast Georgia embayment. In western Georgia, more than 2,000 feet of Upper Cretaceous rocks lie in a trough-like pattern parallel to the outcrops. A short distance to the south, a thinner sequence, 1,000 to 1,500 feet thick, reflects the influence of the Peninsular arch on deposition in Upper Cretaceous time (pl. 9, well FL-52). A wide platform of carbonate deposition extending across the southern one-third of Florida and the Bahama Islands is suggested by the large area of uniform thicknesses between 2,500 and 3,000 feet.

Rocks of Woodbine and Eagle Ford age

Rocks of Woodbine and Eagle Ford age cannot be separated consistently from other Upper Cretaceous rocks in southern Florida, but can be traced from central Florida northward to Long Island along the line of cross section AB (pl. 7). They are reported to be missing in some wells on the crest of the Cape Fear arch (Brown, 1958, p. 38, 43), but may be represented by a 200-foot thick sequence of coarse, nonfossiliferous clastics at the bottom of well NC-58 at Fort Caswell, North Carolina. In central and northern Florida, rocks of Woodbine and Eagle Ford age are represented by the Atkinson Formation, 115 to 266 feet of limestone, sandstone, and shale, which is subdivided into a lower member of Woodbine age and an upper member of Eagle Ford age. Northward, they are represented by the Tuscaloosa and overlying pre-Austin rocks, 563 to 1,850 feet of sandstone and shale, in Georgia, South Carolina, and North Carolina; and by the Raritan Formation, 810 feet of coarse clastics, on Long Island. No formation names are applied here to the correlatives in deep wells in Maryland and New Jersey, although a general equivalence to the Patapsco and Raritan Formations, undifferentiated, is indicated. Considerable confusion and overlap exists in the use of the terms "Patapsco" and "Raritan" on the outcrops between the two states, and somewhat more may exist in the subsurface, as rocks as young as Austin age seem to have been termed "Raritan" in the records of some deep wells. It seems best not to use local terms in the deep wells until problems of correlation along the outcrops are resolved and more deep wells offer paleontologic evidence.

Definitive species of Foraminifera that have been described from the Woodbine Formation in Texas are present in wells along the Atlantic Coast (see table 3). Widely distributed species, *Ammobaculites comprimatus* Cushman and Applin, *Ammobaculites advenus* Cushman and Applin, *Ammotium braunsteini* Cushman and Applin, and *Trochammina rainwateri* Cushman and Applin, occur in wells in Alabama, Florida, Georgia, and South Carolina. *Cuneolina walteri* Cushman and Applin, and *Trocholina floridana* Cushman and Applin, have been identified from depths of 5,090 feet in well FL-57 (Sun Oil Company No. 1 Powell Land Co.) in Volusia County, Florida, and 5,790 feet in well NC-14 (Standard Oil Co. No. 1 Hatteras Light) in Dare County, North Carolina. Abundant specimens of *Acruliammina longa* (Tappan), *Placopsilina langsdalensis* Applin, and *Haplophragmoides langsdalenis* Applin were found at 5,310 feet in beds assigned to the part of the Tuscaloosa Formation that is of Woodbine age in the latter well.

A microfauna closely related to that of the Chispa Summit Formation (Adkins, 1933, p. 437) of Eagle Ford age in Texas is present in wells along the Atlantic Coast (table 3). The species of Foraminifera by which rocks of Eagle Ford age can be most readily identified are *Planulina eaglefordensis* (Moreman), *Valvulineria infrequens* var. (Applin, 1955, p. 196), and *Hastigerinella moremani* Cushman. The occurrence of these species in cores at depths of 3,195 to 3,205 feet in well GA-75 (Sun Oil Co. No. 1 Doster-Ladson), Atkinson County, Georgia, is noted on cross section KL (pl. 13). The interval from 3,155 to 3,387 feet is the type sequence for the upper member of the Atkinson Formation (Applin and Applin, 1947, sheet 3) of Eagle Ford age. Herrick (1961, p. 13) assigned part of this sequence to the Blufftown Formation and part to the Eutaw Formation (Restricted), both of which he considered as Austin in age. However, he identified no fossils below a depth of 3,050 feet, and believes the species named above support an Eagle Ford age for the interval (written commun., 1964).

Rocks of Woodbine and Eagle Ford age crop out almost continuously along the Fall Line from Alabama to New Jersey. They rest directly upon basement rocks at the surface and in the subsurface in a wide area of southern North Carolina, South Carolina, and eastern Georgia (see pls. 16 and 19). Woodbine strata may crop out in the Blake escarpment, opposite Cape Kennedy. A core of dark grayish-green, slightly sandy clay from a depth of 954 fathoms, or 5,724 feet, yielded Foraminifera that Loeblich (*in* Ericson, Ewing, Wollin, and Heezen, 1961, p. 236) regarded as Cenomanian and a little younger than the surface Washita in Texas and Oklahoma (fig. 7). Inasmuch as the Cenomanian Stage of Europe straddles the Lower and Upper Cretaceous boundary and includes rocks of both Washita and Woodbine age in North America, the clay probably is Woodbine in age. It seems likely that rocks of Woodbine and Eagle Ford age may be at or near the bottom surface at many places along the continental slope.

The thickness of rocks of Woodbine and Eagle Ford age penetrated by wells in the Coastal Plain ranges from a few feet to a maximum of 1,812 feet in well NC-14 (Standard Oil Co. No. 1 Hatteras Light) as correlated by Spangler (1950, p. 113, 114) and E. R. Applin (written commun. to J. B. Reeside, Jr., 1957). Offshore (pl. 19), thicknesses may be expected to exceed 1,000 feet in the Southeast Georgia embayment and 2,000 feet in the Baltimore Canyon trough, perhaps by a considerable amount. Uniform thicknesses of less than 250 feet are present over much of the Florida peninsula, perhaps a result of a stable platform in the Florida-Bahama region during Upper Cretaceous time. Rocks of Woodbine and Eagle Ford age are absent on the Peninsular arch in northern Florida and the Cape Fear arch in North Carolina, where rocks of Austin age rest directly upon basement rocks.

Rocks of Austin age

Rocks of Austin age can be separated fairly consistently from overlying rocks of Taylor age in deep wells from central Florida northward to southern New Jersey (pl. 8). Along the line of cross section AB, they range in thickness from 225 to 457 feet between central Florida and the Cape Fear arch, and from 550 to 638 feet between the Cape Fear arch and southern New Jersey. The lithology of the unit changes northward from light-colored limestone beds that cannot be delimited in the dominantly carbonate sequence of Upper Cretaceous rocks in southern Florida to dark-gray shale, siltstone, and sandstone in southern New Jersey. Chalk, marly limestone, and limy sandstone characterize the unit at intermediate points in Georgia and the Carolinas. In well NC-14 at Cape Hatteras, the entire 628-foot sequence is composed of fine- to coarse-grained sandstone with some beds of conglomerate. This represents the lower part of the Black Creek Formation (pls. 8 and 11), a North Carolina unit that encompasses sandstone and shale beds of Austin and Taylor age. In Maryland and New Jersey (pls. 9 and 10), rocks of Austin age, mainly dark-gray shale and sandstone in deep wells, are equivalent to the Magothy Formation, which is dominantly sandstone in shallow wells near the outcrop. They cannot be separated easily from the overlying Matawan Group of Taylor age in deep wells of northern New Jersey and Long Island.

Citharina texana Cushman is the diagnostic species of Foraminifera that most commonly distinguishes the beds of Austin age in Georgia, Alabama, and South Carolina (table 3). In North Carolina, some question seems to exist about the upward range of this species. Spangler (1950, p. 116) stated "*** a macrofauna 'younger than the Austin, perhaps Taylor', was identified by L. W. Stephenson from these beds in the John Wallace well No. 1. As a result, it is thought that *Vaginulina regina* (now *Citharina texana*) ranges into younger beds along the east coast than in the Gulf Coast." Spangler (1950, fig. 5) recorded the occurrence of *C. texana* in several wells from the Black Creek Formation, and he (1950, p. 116, table 2) correlated the Black Creek in North Carolina with the Taylor in the Gulf Coast. However, Spangler and Peterson (1950, p. 8, fig. 4) correlated the Black Creek in North Carolina with both the Austin and the Taylor in the Gulf Coast, and this usage is followed in this report.

In the Florida peninsula, *Citharina texana* Cushman and other time-restricted foraminiferal species, *Globorotalites umbilicatus* Morrow, *Darbyella brownstownensis* Cushman and Deaderick, and *Planulina austiniana* Cushman, are rare, and certain distinctive and widely distributed lithologic features are generally used for recognition of the beds of Austin age.

Kyphopyxa christneri Carsey is present in and frequently recorded from beds of Austin age, but this species is present, also, in the lower part of the beds of Taylor age.

Rocks of Taylor age

The stratigraphic boundaries above and below rocks of Taylor age are discernible in deep wells along the coast in the same area in which rocks of Austin age can be delimited from central Florida to southern New Jersey, except on the Cape Fear arch, where inadequate well records make this uncertain (pl. 9). Along cross section AB (pl. 9), they are thickest in well FL-57 (Sun Oil Co. No. 1 Powell Land Co.) in central Florida, where 860 feet of light-colored limestone beds have been assigned a Taylor age. Applin and Applin (1944, p. 1715) have reported a thickness of more than 1,200 feet in southernmost Florida (Peninsular Oil and Refining Co. No. 1 Cory, Monroe County), but the unit could not be identified readily in the wells used for the cross sections in this report. Thicknesses ranging from 368 to 482 feet are present between central Florida and the Cape Fear arch. North of the Cape Fear arch, the thickness decreases from 585 feet in North Carolina (well NC-49) to 176 feet in Maryland (well MD-14). The composition of the unit changes from limestone in southern Florida to marly limestone and limy shale in central Florida to sandstone and shale in northern Florida and Georgia. Northward, in the deep wells, it is predominantly gray marl, limy shale, and siltstone. In North Carolina, it is represented by the upper part of the Black Creek Formation (pl. 12) and in southern New Jersey by the Matawan Group (pls. 10 and 11). The limits of this group are not apparent in deep wells in northern New Jersey and Long Island (pl. 10), although rocks of Taylor age are most likely present.

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Rocks of Taylor age crop out someplace between depths of 758 and 1,955 feet in a submarine canyon in Georges Bank (See Submarine outcrops and bottom deposits). Material dredged from the wall consisted of poorly sorted, glauconitic and feldspathic, in part silty, coarse-grained sandstone assigned to the Matawan Group. Strata of Taylor age may be exposed or under a thin drape of Cenozoic materials at other places along the continental slope from Georges Bank southward to the Bahama Islands.

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Planulina dumblei (Applin) is the diagnostic species of the beds of Taylor age in the Atlantic Coastal Plain from Georgia northward to Long Island, and it generally occurs near the top of the unit. The highest occurrence of the beds of Taylor age in the Florida peninsula, however, is generally indicated by many specimens of Stensiöina americana Cushman and Dorsey, and Bolivinoides decorata (Jones). S. americana and B. decorata are present in the upper part of the beds of Taylor age throughout the report area except at the southern end of the peninsula. In southern Florida, rocks of Taylor age are present in a thick sequence of very sparsely fossiliferous chalk, but are not differentiated in this report. Planulina dumblei has not been reported from the Florida peninsula, but another species of the Anomalinidae, Anomalina sholtzensis Cole, is fairly common in the peninsula but rare in the part of the Atlantic Coastal Plain north of Florida. Pseudogaudryinella capitosa Cushman is usually found in the lower part of the beds of Taylor age in the northern part of the Florida peninsula and in more northern portions of the report area.

Rocks of Navarro age

Rocks of Navarro age, which mark the top of the Cretaceous rocks, can be traced in deep wells from central Florida northward to Long Island along cross section AB (pl. 9). They have not been separated from the underlying rocks of Taylor age in well NC-58 on the Cape Fear arch, but this is partly because of the inadequate well records in that area. They range in thickness from a maximum of 798 feet in well FL-73 (Humble Oil Co. No. 1 Carroll) in central Florida to a minimum of 70 feet in well NJ-25 (Anchor Gas Co. No. 1 Dickinson) at Cape May, New Jersey.

In northeast and central Florida, rocks of Navarro age are represented by a carbonate facies, 410 to 798 feet thick along cross section AB (pl. 9) and 485 to 900 feet thick along cross section MN (pl. 15). This facies has been termed the Lawson Limestone, and divided into upper and lower members by Applin and Applin (1944, p. 1708). The lower limit of the Lawson Limestone is not distinct in wells in southern Florida, where the entire Upper Cretaceous sequence is composed of lithologically similar carbonates.

Northward from Florida, the rocks of Navarro age grade into chalk, marl, and fine-grained clastics containing large amounts of glauconite. The Peedee Formation in North Carolina, which is Navarro in age, is 114 to 212 feet thick along cross section AB and consists primarily of marl, calcareous and siliceous shale, and fine-grained sandstone. The Monmouth beds, 70 to 170 feet thick, in wells along cross section AB in Maryland, New Jersey, and New York, are Navarro in age. They are primarily dark-colored silty and sandy clay, and greenish glauconitic clay and sandy clay at the extremity of cross section AB in Long Island (Perlmutter and Todd, 1965, p. I-7).

Submarine outcrops of Navarro age are present in two canyons cut in Georges Bank (see Submarine outcrops and bottom deposits). Fragments of dark-colored micaceous silty clay, coarse greensand and micaceous fine-grained sandstone, characteristic Navarro Foraminifera, were dredged from the walls someplace between depths of 1,738 and 3,116 feet. Similar outcrops probably exist in other canyons along the continental slope.

Published reports on planktonic species of Foraminifera show that occurrences of the genus Globotruncana are restricted to beds of Cretaceous age. Consequently, the highest indigenous occurrence of the genus in a set of well samples is prima facie evidence of the Cretaceous age of the containing beds. Globotruncana arca Cushman, and Globotruncana cretacea Cushman are the species generally found in the samples from the wells that are shown on the cross sections in this report. Because these species range downward into beds older than Navarro, and are not always present at the top of the unit, other species, such as Anomalina pseudopapillosa Carsey, Cibicides harperi (Sandidge), and Robulus navarroensis Cushman reported only from the Navarro, have been used to delimit the rocks of Navarro age.

The Lawson Limestone of Navarro age in the Florida peninsula differs in lithologic character and in microfaunal population from the clastic beds of equivalent age in the Coastal Plain of the Middle Atlantic States. The fauna of the lower member of the Lawson Limestone is characterized by several species of Lepidorbitoides found also in the Maestrichtian of Europe, the Madruga Chalk of Cuba, and the Cardenas beds of Mexico. Sulcoperculina cosdeni Applin and Jordan is another definitive species. Specimens of Globotruncana cretacea are present but rare, and specimens of Anomalina cosdeni Applin and Jordan are common in some wells. The upper member of the Lawson Limestone is generally highly altered chemically, and specifically determinable fossils are rare. Rudistid fragments are commonly found near the top of the member and are fairly common at irregularly spaced lower levels. Specimens of a small, undescribed Rotalid are also fairly common in the upper Lawson.

The reported stratigraphic ranges of most of the Cretaceous species of smaller Foraminifera mentioned in this report are given by Cushman (1946).

Cenozoic rocks

Outcrops of Cenozoic rocks parallel the Fall Line from Georgia to New Jersey except in South and North Carolina where the outcrops swing seaward around the flanks of the Cape Fear arch. Cenozoic deposits are thickest in the southern Florida-Bahamas region, as shown on plate 20. Thicknesses in excess of 4,000 feet are present in wells in the southern half of the Florida peninsula, and a thickness of 8,220 feet is present in well BA-2 (Bahamas Oil Co., Ltd. No. 1 Andros Island) in the Bahamas (pl. 16). Along cross section AB (pl. 9), which parallels the Atlantic Coast, the thickness of Cenozoic rocks ranges from 4,307 feet in southern Florida (well FL-86) to 254 feet on the Cape Fear arch (well NC-58); and from 3,020 feet at Cape Hatteras (well NC-14) to 130 feet on Long Island (well NY-6). Beneath the Continental Shelf, Cenozoic thicknesses well in excess of 3,500 feet and 6,000 feet may be present in the Southeast Georgia embayment and the Baltimore Canyon trough respectively, judging by the rate of thickening onshore and scattered seismic profiles (pl. 6).

The Cenozoic rocks have been subdivided into Paleocene, Eocene, Oligocene, Miocene, and post-Miocene units in this report. In some wells, mostly in Florida and Georgia, rocks of Wilcox, Claiborne, and Jackson age have been recognized within the Eocene. The Miocene rocks are partially subdivided in wells in North Carolina, Maryland, and New Jersey. Rocks of Pliocene, Pleistocene, and Recent age are not separated and are grouped together as post-Miocene rocks in this report.

Tertiary rocks

In general, the Tertiary rocks are dominantly carbonates in Florida but grade northward into heterogeneous sequences of limestone, marl, limy shale, sandstone, and clay. Thick beds of limestone and sandstone characterize the sequence in well NC-14 at Cape Hatteras, which is farther down the regional dip than the other wells. The faunal assemblages in the carbonate rocks of Tertiary age in the Florida peninsula are most closely related to faunal groups of equivalent age in Cuba, Panama, and other parts of the Caribbean and Central American region. The faunal groups of the northern part of the report area resemble most closely those of west Florida and the central and western Gulf Coast. A few of the distinctive Florida species are reported, also, from Tertiary beds in the subsurface in Georgia.

9.1267

Paleocene rocks

Paleocene rocks, equivalent to the Midway Group of the Gulf Coast, are present along the lines of all cross sections of this report, but are absent or indistinguishable from Eocene rocks in some wells near the Fall Line and on the Cape Fear arch. They are apparently overlapped by younger Tertiary rocks toward the Fall Line in northern Georgia (pl. 13). A maximum thickness of 2,270 feet has been tentatively assigned to rocks of Midway age in well BA-2 on Andros Island (pl. 16).

Along cross section AB (pl. 9), the Paleocene rocks range in thickness from 1,210 feet in well FL-104 in southern Florida to a wedge edge on the flanks of Cape Fear arch. They are relatively thin, less than 190 feet thick, and less readily identified north of the Cape Fear arch. The Paleocene rocks in Florida are represented by the Cedar Keys Limestone, a light-colored limestone containing *Borelis* as a common fossil. The equivalent formation in Georgia and South Carolina is the Clayton Formation, which is composed mainly of marl, sandy limestone, and limy sandstone beds. This correlates with the Beaufort Formation in North Carolina, a sequence of gray glauconitic shale interbedded with thin limestone and chert beds. Farther north, identification of Paleocene rocks is difficult. The sequence tentatively assigned to this age in well NJ-26 at Island Beach, New Jersey, is composed mostly of dark greenish-gray fossiliferous limy clay and gray glauconitic siltstone. The underlying beds of Navarro age (Monmouth Formation) have a similar appearance and the two units can be separated only by means of fossils.

The foraminiferal species *Borelis gunteri* Cole and *Borelis floridanus* Cole are key species of the Cedar Keys Limestone (Cole, 1944, p. 28) of Paleocene age in the Florida peninsula. These species, and additional ones that have been described (Applin and Jordan, 1945) from the Cedar Keys, were present in many Florida wells used on cross sections herein (table 3).

Species described from and generally restricted to rocks of Paleocene age were found in Georgia, South Carolina, Maryland, and New Jersey. The most common species are *Robulus pseudo-mamilligerus* (Plummer) Cushman, *Vaginulina longiforma* (Plummer) Cushman, *Anomalina midwayensis* (Plummer) Cushman, and *Robulus midwayensis* (Plummer). The latter species has also been reported from the Salt Mountain Limestone and from the Nanafalia Formation, both of lower Wilcox, lower Eocene age in Alabama (Toulmin, 1941, p. 579).

Beneath the sea off Georgia and Florida, Paleocene strata are known to extend under the Shelf and Blake Plateau (See Offshore test holes). JOIDES test hole 4 (FL-122) on the Blake Plateau penetrated 263 feet of these beds between depths of 322 and 585 feet, where drilling ceased. Cores from this hole consisted principally of hard, cherty, very fine-grained limestone interbedded with gray limey clay. JOIDES test hole 6 (FL-121), also on the Blake Plateau, was drilled only 10 feet into Paleocene strata.

Paleocene strata may crop out for considerable distances along the Blake escarpment. Dolomitic limestone and limestone beds from 5,950 to 8,220 feet deep beneath Andros Island in the Bahamas (well BA-2, pl. 15) have been assigned a Paleocene age. Judging by the close proximity of the Northeast Providence channel and Tongue-of-the-Ocean (5 to 10 miles), which descend to depths of about 10,000 feet, similar thicknesses of Paleocene strata may crop out or be thinly mantled along these canyon walls, which connect to the Blake escarpment.

Eocene rocks

Eocene rocks crop out as a continuous band in the Coastal Plain from Alabama to the Cape Fear arch. They are absent from the crest of the arch, and somewhat intermittently exposed through overlying Miocene rocks northward to Long Island. Eocene rocks are present in most of the wells on the cross sections. They are thickest in wells off southern Florida (pl. 16), where they range from 2,000 to 4,000 feet in thickness, and are thinnest in Maryland (pl. 11), where they are 100 to 350 feet thick.

Along cross section AB (pl. 9), the Eocene rocks range in thickness from 2,328 feet in well FL-86 to 176 feet in well NC-58 on the Cape Fear arch, and from 1,132 feet in well NC-14 at Cape Hatteras to less than 500 feet in New Jersey. The Eocene rocks are mostly limestone in Florida. In central and northern Florida, they are subdivided in ascending order into the Oldsmar Limestone of Wilcox age, the Lake City and Avon Park Limestones of Claiborne age, and the Ocala Limestone of Jackson age. The Eocene rocks in Georgia and South Carolina consist of limestone, marl, and sandstone beds for the most part. Rocks of Wilcox, Claiborne (Lisbon and Talahatta Formations), and Jackson age are readily separable in this area. Farther northward, Eocene rocks exhibit a gradual change from sandy limestone and sandstone beds in North Carolina into a shale and sandstone sequence in Maryland and New Jersey. Limestones of middle and upper Eocene age can be separated from lower Eocene rocks in North Carolina wells, but in Maryland and New Jersey wells on cross section AB (pl. 9) the Eocene rocks are neither readily subdivided nor easily distinguished from the overlying Miocene rocks.

Several of the species of Foraminifera that characterize lower Eocene rocks (Oldsmar Limestone) found in wells in northern and central Florida are *Pseudophragmina cedarkeysensis* Cole, *Coskinolina elongata* Cole, *Miscellania nassauensis* Applin and Jordan, and *Helicostegina gyralis* Barker and Grimsdale. The latter species is known to occur in the basal part of the middle Eocene (Cole and Applin, 1964, p. 14), as well as in the lower Eocene. Foraminiferal species that have been described from outcropping sediments of Wilcox, lower Eocene age were recovered from samples from wells drilled in the Coastal Plain in the Middle Atlantic States (table 3). Among these species are *Eponides dorfi* Toulmin, *Spiroplectammina wilcoxensis* Cushman and Ponton, *Alabamina wilcoxensis* Toulmin, and *Pseudophragmina stevensoni* (Vaughan).

The middle Eocene rocks in the report area contain many foraminiferal species that are stratigraphically restricted to the unit, but differ in their geographic distribution. Species that have been reported from wells in both Florida and Georgia are: *Asterocyclina monticellensis* Cole and Ponton, *Discorbis inornatus* Cole, *Gyroidina nassauensis* Cole, *Discorinopsis gunteri* Cole, *Amphistegina lopeztrigoi* D. K. Palmer, *Asterigerina texana* (Stadnichenko), *Cibicides westi* Howe, and *Lepidocyclina antillea* Cushman. The well-known definitive species *Eponides mexicanus* Cushman is present in middle Eocene beds at the depth of 2,572 feet in the Gulf Oil Corp. No. 1 State of Florida Lease 826-G, in Florida Bay, Monroe County, Florida, and is common in middle Eocene beds at the depth of 2,610 feet in the Anchor Gas Co. No. 1 Dickinson well at Cape May, New Jersey. A few species that have been reported only from Florida are: *Dictyoconus americanus* (Cushman), *Fabularia vaughani* Cole and Ponton, *Lockhartia cushmani* Applin and Jordan, *Lepidocyclina cedarkeysensis* Cole, *Dictyoconus floridanus* (Cole), *Lituonella floridana* Cole, *Spirolina coryensis* Cole, and *Flintina avonparkensis*. The recurrence of *Dictyoconus floridanus* in the middle Eocene rocks in the Florida peninsula has been mentioned in the discussion of rocks of late Trinity age.

Definitive species reported from upper Eocene rocks in Florida and Georgia, and found in wells on the cross sections of this report are: *Lepidocyclina ocalana* Cushman, *Heterostegina ocalana* Cushman, *Operculinoides floridensis* (Heilprin), *Operculina mariannensis* Vaughan, *Camerina moodysbranchensis* Gravell and Hanna, *Amphistegina cosdeni* Applin and Jordan, *Sphaerogypsina globula* (Reuss), *Asterocyclina nassauensis* Cole, and *Eponides jacksonensis* Cushman and Applin. In addition, *Bulimina jacksonensis* Cushman and *Uvigerina cocoaensis* Cushman are present in samples from wells in Florida and from the Anchor Gas Co. No. 1 Dickinson well at Cape May, New Jersey. Additional upper Eocene species in the Anchor Gas Co. well are: *Marginulina cooperensis* Cushman at 1,420 feet, *Eponides cocoaensis* Cushman at 1,520 feet, and *Robulus virginianus* Cushman and Cederstrom at 1,520 feet. Cushman (1948, p. 228, 234, and 240) ~~also~~ reported the occurrence of *M. cooperensis*, *E. cocoaensis*, and *B. jacksonensis* in the Ohio Oil Co. No. 1 L. G. Hammond well, ~~No. 1,~~ Wicomico County, Maryland, and on the basis of Foraminifera, upper Eocene strata have been reported from several additional wells in Maryland (Anderson, 1948, p. 85-86, and p. 94; Shifflet, 1948, p. 25-26).

The wide distribution of rocks of Eocene age beneath the Shelf and Blake Plateau has been established by bottom cores along the continental slope from Georges Bank southward to the Bahama Islands, by a deep well on Andros Island, and the test holes drilled offshore from Georgia and Florida. Two bottom cores of probable Jackson age were taken from the middle of the continental slope 90 miles southeast of Marthas Vineyard, two of upper Eocene age from the lower continental slope near Hudson Canyon, and one of upper Eocene age from the Blake escarpment. Limestone, dolomitic limestone, and dolomite beds present in the Andros Island well (BA-2) between depths of 1,950 and 5,950 feet very likely are represented in the nearby canyon wall of Northeast Providence channel and the Tongue-of-the-Ocean.

The U. S. Coast Guard test hole (well GA-88) off Georgia penetrated only 5 feet of upper Eocene rocks, the Ocala Limestone (McCollum and Herrick, 1964, p. C61-62). In onshore wells in Chatham County, the Ocala is about 400 feet thick and consists of gray to buff fossiliferous limestone. It is the principal aquifer throughout much of eastern Georgia. No facies change was noted in the Ocala between the coastal wells and the offshore test hole.

The JOIDES test holes (FL-118-123, fig. 7) off Jacksonville, Florida, penetrated 48 to 550 feet of Eocene rocks. Only two test holes, 6 and 4 (FL-121 and 122), drilled completely through the Eocene sequence. Test hole 6 (FL-121) about 136 miles offshore near the middle of the Blake Plateau penetrated 63 feet of lower Eocene beds, 35 feet of middle Eocene beds, and 95 feet of upper Eocene beds. Test hole 4 (FL-122), located about 221 miles offshore near the edge of the Blake Plateau, found only 53 feet of Eocene beds, all of which were assigned an early Eocene age.

Thicknesses in excess of 550 feet were penetrated in test holes 1 and 2 (FL-118 and 119), about 27 and 64 miles respectively offshore on the Continental Shelf. These included only beds of late and middle Eocene age, mainly porous medium-to-coarse clastic limestones and dolomitic limestones. Early Eocene beds are present in onshore wells and in test holes 6, 3, and 4 (FL-121, 122 and 123) farther out on the Blake Plateau, which suggests that the two test holes on the Shelf would have reached early Eocene rocks if drilling had continued. Test hole 3 (FL-123) about 181 miles offshore on the outer Blake Plateau opposite Cape Kennedy penetrated 85 feet of middle and lower Eocene rocks, composed mainly of limy sand, fine-grained limestone, chert, and clay. About 75 miles north on the outer Blake Plateau, test hole 4 (FL-122) drilled 55 feet of lower Eocene ooze and chert. The lithology and thickness of lower, middle, and upper Eocene units in the JOIDES test holes suggest that Eocene rocks became less porous and thin seaward both internally and by loss of beds at the top.

Oligocene rocks

Oligocene rocks are present both at the surface and in the subsurface from Florida northward to the Cape Fear arch. They are not known at the surface north of the Cape Fear arch, but may be present in the interval marked "Rocks of uncertain age, possibly Oligocene in part" in wells NC-7 and NC-14 in North Carolina (pls. 9 and 12). The Oligocene rocks are composed of limestone beds from 35 to 250 feet thick south of the Cape Fear arch. The rocks of uncertain age, possibly Oligocene in part, in wells NC-14 and NC-7 in North Carolina include sandy limestone, shale, and sandstone beds. Considerable additional study of this interval is needed.

The Oligocene rocks in Florida and Georgia contain closely similar faunal populations. Among the larger Foraminifera, *Heterostegina antillea* Cushman, and *Miogypsina gunteri* Cole are probably the most important faunal elements in southern Florida, and *L. undosa* and *M. gunteri* have also been reported from wells in the Georgia Coastal Plain. Of the smaller foraminiferal species, *Streblus mecatepecensis* (Nuttall) and *Streblus byramensis* (Cushman) are probably the most abundant and the most widely distributed. Specimens of *Asterigerina subacuta* Cushman and *Nonionella leonensis* Applin and Jordan are common.

An unusual but characteristic feature of the Oligocene rocks in Florida and Georgia is the common occurrence of specimens of *Dictyoconus floridanus* and *Discorinopsis gunteri*. Both are diagnostic fossils of the upper middle Eocene Avon Park Limestone in the Florida peninsula. Their recurrence in the Oligocene of Florida and Georgia has been attributed to secondary deposition by Cole (1941, p. 12-16), although Applin and Applin (1944, p. 1682-1683), among others, suggest that these fossils may be indigenous. Because they are generally accompanied by many specimens of *Streblus mecatepecensis* and other typical Oligocene species, the age of the containing beds is readily determinable.

Offshore, the Oligocene rocks have been recovered from the Blake escarpment and penetrated by test holes on the Shelf and Blake Plateau (fig. 7). The U. S. Coast Guard test holes (well GA-88) off Georgia drilled through about 76 feet of limy sand of Oligocene age between depths of 90 and 166 feet below sea bottom. Oligocene rocks appear to grade from fossiliferous limestone in inland wells to sandy limestone in coastal wells and then into limy sandstone offshore. This facies change may be related to the development of the upwarp along shore mapped on a Miocene limestone by McCollum and Counts (1964, pl. 1).

Considerable thicknesses of Oligocene rocks were drilled in the six JOIDES test holes off Jacksonville, Florida (figs. 7 and 8). The thicknesses recorded increase from 30 feet in test hole 1 (FL-118) about 27 miles offshore to 532 feet in test hole 5 (FL-120) about 76 miles offshore and then decrease to 170 feet in test hole 3 (FL-123), 181 miles from shore, and only 94 feet in test hole 4 (FL-122), 221 miles from the coast. The maximum thickness is near the edge of the present-day Shelf.

Miocene rocks

Only a few large patches of Miocene deposits are exposed on the surface of the Coastal Plain south of the Cape Fear arch. These include areas the size of one-to-three counties in South Carolina, and along the Gulf side of Florida. North of the Cape Fear arch, broad, flat-lying Miocene deposits blanket the Coastal Plain from North Carolina across the Salisbury embayment to the northeastern tip of New Jersey.

Subsurface Miocene rocks along the line of cross section AB (pl. 9) are about 800 feet thick in the Florida Keys (well FL-104), less than 60 feet thick at the Peninsular arch (well FL-57), and about 350 feet thick in the Southeast Georgia embayment (well GA-87). They wedge out in South Carolina on the flank of Cape Fear arch. In this interval the lithology changes gradually from chalky, coquinoidal limestone to dark sandy limestone and claystone. North of the Cape Fear arch, the Miocene rocks reach a thickness in excess of 1,300 feet at Cape Hatteras (well NC-14) and about 1,400 feet in the center of the Salisbury embayment (well MD-14). Miocene rocks are not delimited in the Tertiary sequence in well NJ-26 in northeastern New Jersey, and are not present in well NY-6 on Long Island. The lithology grades northward from sandy limestone and sandstone to clay, sand, and gravel.

Lower Miocene rocks are separated from middle and upper Miocene rocks in wells NC-14 and NC-7 in North Carolina on cross section AB (pl. 9), but are not identified in well MD-14 in Maryland and well NJ-25 in New Jersey. Lower, middle, and upper Miocene rocks are separated on cross section GH (pl. 12) in North Carolina. Local formation names -- Calvert, Choptank, St. Marys, and Yorktown -- are applied to the shallow subsurface Miocene rocks in Maryland on cross section EF (pl. 11).

The foraminiferal faunas of the Miocene rocks of the Atlantic and eastern Gulf Coastal Plain have been described in several comprehensive reports. Pertinent references to Miocene Foraminifera that are useful in connection with the present report are by Cushman and Cahill (1933), Puri (1953), and in paleontological reports by J. A. Cushman (1948, p. 214-225) and by Ann Dorsey (1948, p. 268-321). Only a few of the most common diagnostic species of Miocene Foraminifera are shown in table 3 in this report, and most of these faunal data relate to wells in the southern part of the Florida peninsula. However, a few data are available on Miocene Foraminifera from a well in Maryland, and from the Anchor Gas Co. No. 1 Dickinson well in New Jersey.

A few of the species of smaller Foraminifera present in wells in Florida are: *Globoratalia menardii* (d'Orbigny), *Buccella mansfieldi* (Cushman), *Robulus americanus* (Cushman), *Hazawaia concentrica* (Cushman), *Elphidium chipolense* (Cushman), *Peneroplis bradyi* Cushman, *Amphistegina chipolensis* Cushman and Ponton, *Textulariella barretti* (Jones and Parker), *Archaias floridanus* (Conrad), and *Sorites*(?) sp.(?) Cushman and Ponton.

Several species of larger Foraminifera that are important elements in the fauna are: *Miogypsina antillea* (Cushman), *Miogypsina staufferi* Koch, and *Lepidocyclina* (*Eulepidina*) *yurnagunensis* Cushman.

Cole and Applin (1961, p. 130-131) discussed the stratigraphic distribution of some larger Foraminifera in Florida, and showed that certain species of *Miogypsina* are confined to the upper Oligocene, certain other species are confined to the lower Miocene, possibly the basal Tampa Limestone, and some species are common in both the upper Oligocene and lower Miocene. Consequently, the occurrence of the genus *Miogypsina*, alone, is not indicative of either stratigraphic unit.

Common species of smaller Foraminifera present from 920 to 1,080 feet in the Anchor Gas Co. well at Cape May, New Jersey, are: *Cibicides floridanus* (Cushman), *Nonion mediocostatum* (Cushman), *Nonion pizarrense* W. Berry, *Spiroplectammina mississippiensis* (Cushman), *Textularia mayori* Cushman, and *Uvigerina subperegrina* Cushman and Kleinpell.

The sea bottom off the Atlantic Coast has yielded cores and samples of Miocene deposits at many places (see Submarine outcrops and bottom deposits). Miocene strata beneath the Shelf, Blake Plateau, and Bahama Islands have been penetrated and sampled by the test holes off Georgia and Florida, and by wells drilled on the Bahama Islands (BA-2 and 3).

Greenish, fine-grained sandstone probably from the Yorktown Formation of middle-to-upper Miocene age was found in place along the east wall of Lydonia canyon in Georges Bank at a position high on the continental slope. Talus of Miocene age has been recovered from nearby Hydrographer and Corsair canyons at positions on the upper and middle continental slope. Nearshore shoals called "Black Rocks" at Cape Fear arch have been identified as marl of Miocene age. Ooze of Miocene age has been dredged from numerous locations on the top of the Blake Plateau, and three cores of Miocene deposits have been recovered from the edge of the Blake Plateau and escarpment (fig. 7).

A Miocene sequence, 80 feet thick, was drilled in the U. S. Coast Guard test hole (GA-88, fig. 7) off Georgia. McCollum and Herrick (1964, p. C63) subdivided this into lithologic units of lower, middle, and upper Miocene age. They report the lower Miocene unit to be a fossiliferous phosphatic sandy conglomeratic limestone, 12 feet thick. This limestone persists over a wide area inland and has been used by McCollum and Counts (1964, pl. 1) for structural mapping in ground-water investigations. Unconformably overlying this limestone are beds of pale-green phosphatic sandy clay and clayey sand, 50 feet thick, that are considered middle Miocene in age. The upper Miocene unit, 18 feet thick, consists of sand, clay, and a layer of sandy dolomitic limestone. The Miocene sequence thins seaward to the test hole, mainly at the expense of the upper Miocene beds.

Miocene rocks, consisting mainly of phosphatic silt and clay with phosphate pebbles, were drilled and cored in four of the six JOIDES test holes off Jacksonville, Florida (fig. 7). Test holes 1 (FL-118) and 2 (FL-119), about 27 and 63 miles offshore on the Shelf, recorded 238 and 258 feet of Miocene rocks, respectively. Middle Miocene deposits are missing at test hole 2 (FL-119) on the outer Shelf but marked by a phosphate pebble zone. Test hole 5 (FL-120), 77 miles offshore near the top of the continental slope, and test hole 6 (FL-121) about 136 miles offshore near the middle of the continental slope, did not record any Miocene rocks but went from post-Miocene deposits directly into a thick Oligocene sequence. Miocene sequences, 260 to 115 feet thick, were logged in test holes 3 (FL-123) and 4 (FL-122), 181 and 221 miles offshore on the outer Blake Plateau. Only lower Miocene rocks were recognized in test hole 4 (FL-122).

A vuggy-to-cavernous limestone and dolomite sequence, 1,420 feet thick, is present in well BA-2 on Andros Island in the Bahamas. A water well (BA-3) on the nearby Eleuthera Island is reported to have drilled 250 to 300 feet into similar rocks of Miocene age. In general, the Miocene deposits seem to be at or near the top of the Shelf, outer Blake Plateau and escarpment. They are absent from the Florida-Hatteras slope and the innermost Blake Plateau where the JOIDES test holes were drilled off Jacksonville.

Tertiary and Quaternary deposits

Post-Miocene deposits

Pliocene, Pleistocene, and Recent deposits along the Atlantic Coast are represented by beds of marl, clay, sand, and gravel that cannot be readily separated on an age basis in the scattered wells of these cross sections. These are treated as undifferentiated post-Miocene rocks.

The thickest sequence of post-Miocene rocks, 530 feet thick, on these cross sections is present on Andros Island (well BA-2, pl. 16). Thicknesses in excess of 250 feet are present in wells on the Florida Keys (wells FL-109 and FL-111, pl. 16). The rocks are predominantly marl in Florida and the Bahamas. Along cross section AB (pl. 9), the thickness exceeds 200 feet only in the Salisbury embayment (well NC-7 and well MD-14). Sand and gravel beds predominate in this area.

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The U. S. Coast Guard test holes (GA-88) off Georgia revealed very thin, undifferentiated post-Miocene deposits on the Shelf there. Fossiliferous sand, only 10 feet thick and possibly all Recent in age, was logged above the Miocene rocks. The six JOIDES test holes off Jacksonville, Florida, penetrated thicknesses of post-Miocene deposits ranging from 20 feet in test hole 6 (FL-121), 136 miles offshore on the Blake Plateau, to 220 feet in test hole 5 (FL-120), 76 miles offshore near the edge of the Shelf. The maximum deposition of sediments in this offshore area in post-Miocene time appears to have been at or near the edge of the present-day Shelf.

Petroleum potential

Hydrocarbons and source beds

Oil and gas have not been discovered in commercial quantities in the Atlantic Coastal Plain and Continental Shelf, but three accumulations have been found along the eastern edge of the Gulf Coastal Plain in the southwestern part of the Florida peninsula. These are the Sunniland field in Collier County, the Forty-Mile Bend field in Dade County, and the Felda field in Hendry County (pl. 1).

Sunniland field, Collier County, Florida, was discovered in 1943 after intensive exploration with seismograph, gravity meter, and core drilling (Hughes, 1944, p. 804). The early history of this field has been described by Gunter (1946, p. 1-4; 1949, p. 310-312; 1950, p. 1-5), Puri and Banks (1959), and Roberts and Vernon (1961, p. 218). The discovery well, the Humble Oil and Refining Co. No. 1 Gulf Coast Realties Corp., in sec. 29, T.48S., R.30E., produced 110 barrels of 20° A.P.I. gravity oil and 475 barrels of salt water a day by pumping from depths of 11,613 to 11,626 feet in the Sunniland Limestone of Trinity age (Lower Cretaceous). The field was developed by drilling a total of 20 wells between 1943 and 1950. Thirteen wells were successful, with initial production tests ranging from 97 to 527 barrels of oil a day.

The reservoir, the Sunniland Limestone, lies "above the thick anhydrite bed in the Trinity, which is equivalent to some part of the Glenrose formation of Texas" (Jordan, 1954, p. 375). Puri and Banks (1959, p. 123) state that the trap is formed by a small fold not evident in the rocks above 5,000 feet. They ascribe 150 feet of relief to the structure at a depth of 11,500 feet, but explain that tilting to the northeast by 50 feet a mile has reduced the fold closure to only 36 feet.

According to Roberts and Vernon (1961, p. 218), two of the producing wells had been abandoned by 1960, and the remaining 11 wells pumped an average of 96 barrels a day. They state that the cumulative production for the Sunniland field was 6,089,470 barrels at the close of 1960, and that the best well had produced over 800,000 barrels, and the average well over 400,000 barrels. On March 1, 1965, Sunniland field was producing 1,800 barrels of oil and 3,600 barrels of salt water a day by pumping, and the cumulative production reached 8,475,830 barrels of oil (Kornfeld, 1965, p. 173). Pumping costs have been relatively low because of an efficient water drive.

Forty-Mile Bend field, Dade County, Florida, was discovered in 1954 about 50 miles southeast of the Sunniland field after both reflection and refraction seismic surveys had been made in the area (Powell and Culligan, 1955, p. 1008). The discovery well, the Gulf Refining Company No. 1 Wiseheart-State of Florida, sec.16, T.54S., R.35E., reached a total depth of 11,557 feet and was completed in the Sunniland Limestone of Trinity age (Lower Cretaceous). The initial production was 76 barrels of 20° A.P.I. gravity oil and 96 barrels of salt water from depths of 11,322 to 11,339 feet. A second producing well completed with an initial production of 112 barrels a day was followed by three dry holes that delimited the small field. The field produced a total of 32,888 barrels of oil before being abandoned (Roberts and Vernon, 1961, p. 218).

Felda field, Hendry County, Florida, about 15 miles northwest of the Sunniland field, was discovered in 1964 near the Town of Felda. The discovery well was the Sun Oil Company No. 2 Red Cattle Company in Sec. 32, T.45S., R.29E. Its initial flow was 111 barrels of 24.5° A.P.I. gravity oil from the interval of 11,471 to 11,485 feet in the Sunniland Limestone (Gardner, 1964, p. 175). A second producing well was drilled to a total depth of 11,495 feet about $1\frac{1}{4}$ miles southeast of the discovery, and a third successful well was drilled about $\frac{1}{4}$ mile southeast of the first well. The third well, which is the best so far, had an initial pumping potential of 336 barrels of oil and one barrel of salt water. The cumulative production of Felda field reached 42,903 barrels of oil on March 1, 1965 (Kornfeld, 1965, p. 173).

Although petroleum has been produced in three counties of southern Florida, little evidence of hydrocarbons has been found in the many wells drilled in northern Florida. The St. Mary's River Oil Corporation No. 1 Hilliard well (Well 51, Table 1) in Nassau County was reported to have asphaltic staining in the Cedar Keys Limestone of Paleocene (Tertiary) age, in limestones of Taylor (Upper Cretaceous) age, and in the lower part of the Atkinson or Tuscaloosa Formation of Woodbine (Upper Cretaceous) age. However, these shows must be regarded as doubtful in view of the State Geologist's statement (Vernon, 1951, p. 238) that "shows of oil and gas are unknown throughout the northern Peninsula".

Indications of hydrocarbons have been reported in two wells in southwestern Georgia, an adjacent part of the Gulf Coastal Plain. Shows of both oil and gas were reported without confirmation at unspecified depths in the J. R. Sealy No. 3 Spindle Top well (Well 65, Table 1) in Seminole County. This well was abandoned in Lower Cretaceous rocks at a total depth of 7,620 feet. Records of the second well, the J. R. Sealy No. 1 Fee well (Well 67, Table 1), Decatur County, show that an unknown quantity of gas and hot water flowed from an Upper Cretaceous sandstone at a depth of 3,005 feet. The calculated heating value for this gas was only 754 B.T.U. per cubic foot. Results of the analysis are given below:

Methane	74.2%
Nitrogen	24.1%
Carbon dioxide	0.6%
Argon	0.4%
Helium	0.3%
Oxygen	0.2%
Hydrogen	0.1%
Ethane	0.1%
Cyclopentane	trace

Seeps and shows of oil have been reported in central Georgia. The seeps occur in the vicinity of Scotland, Telfair County, where oil of about 30° A.P.I. gravity and gas come to the surface in a swampy area (Hull and Teas, 1919). The surface beds are sands and clays of probable Oligocene age in an area that may be structurally high, according to Hull and Teas (1919, p. 11). The oil shows have been reported, without confirmation, in Coffee and Telfair Counties. A show of oil in a sandstone of Taylor age was reported in a Carpenter Oil Company well about 20 miles north of Douglas in Coffee County, and fluorescence and staining was reported in sidewall cores taken from sandstones of Lower Cretaceous(?), Woodbine, and Austin age in the Parsons and Hoke No. 1 Henry Spurlin well (well GA-33, table 1) in Telfair County.

A few oil seeps and surface indications of gas have been reported in North Carolina, but none have been substantiated. Subsurface evidence for the presence of hydrocarbons is also very meager. Scattered shows of oil were reported by the driller in cuttings and sidewall cores of the F. L. Karsten No. 1 Laughton well (well NC-47, table 1) located near the coastline in Carteret County, but were not confirmed by later studies of the samples and cores. "Showings of a gas" of unspecified composition in Lower Cretaceous or possibly Triassic rocks between depths of 3,170 and 4,050 feet in the Du Grandlee Exploration Co. No. 1 Foreman well (well NC-12, table 1) in Camden County were reported to Richards (1954, p. 2565).

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A minor amount of gas was produced from shallow wells in the Coastal Plain of Maryland and used as fuel for a period of two years near the turn of the century. These wells, located in the vicinity of Parsonburg and Pittsville in Wicomico County, were less than 100 feet deep. The gas produced had a high nitrogen content (77.96 percent) and a low methane content (19.86 percent). It was concluded that this gas was marsh gas and had its origin in a buried swamp. No gas was reported below these shallow depths. Reference to well MD-12 on cross section EF (pl. 10) of this report suggests that the gas came from Pleistocene or Pliocene alluvium.

Traces of hydrocarbons were detected at a depth of 300 feet in a water well at Cape May, New Jersey, and in another water well at Atlantic City, by F. J. Markewicz of the New Jersey Geological Survey, according to M. E. Johnson (Petroleum Week, 1958, p. 23). A similar occurrence in another water well near Cape May was reported to him by an oil company geologist.

Source beds for hydrocarbons, generally regarded to be marine shales, marls, and limestones in about that order of importance, are scattered throughout the stratigraphic sequence beneath the Coastal Plain, but only reach considerable thicknesses beneath the Florida peninsula and in a narrow band along the coast from New Jersey to North Carolina. Thick limestone, marl, and dolomite beds make up most of the Cretaceous and Tertiary rocks in Florida and southern Georgia; shale, marl, and limestone beds make up more than half of the sequence at Cape Hatteras and in coastal Maryland. Offshore, much thicker marine deposits, particularly in the Lower Cretaceous and older rocks, may be expected beneath the Continental Shelf. Inland, the rocks with more continental aspects probably are more likely to be sources of dry gas than of oil.

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Emery (1963, p. 6; 1965, p. C159-C160) has suggested that fine-grained organic-rich source beds may be interbedded with coarse-grained turbidites at the base of the continental slopes of the world and that possibly large reserves of petroleum will be found there when cheap and effective methods of drilling and extraction at such water depths are developed. If this is established, a band of sediments along the slope and rise from Newfoundland to Florida will deserve consideration for petroleum exploration.

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Reservoirs and fluids

Reservoirs are thick and numerous beneath the Atlantic Coastal Plain. Sandstones of Upper Cretaceous age and sandstones and limestones of Tertiary age supply fresh water to most of the communities on the Coastal Plain. The Upper Cretaceous sandstones, especially those of Woodbine and Austin age that are several hundred feet thick, yield large quantities of potable water for several tens of miles downdip from their outcrops. Sandstones of the Raritan (Woodbine age) and Magothy (Austin age) Formations cropping out along the Fall Line in New Jersey have porosities as large as 46 and 40 percent respectively (Barksdale and others, 1958, p. 98). Generally, the Upper Cretaceous sandstones contain salt water near the coast, although fresh-to-brackish water is present in the Raritan Formation along the New Jersey coast (Gill, Seaber, Vecchioli, and Anderson, 1963, p. 20) and the southern shore of Long Island (Perlmutter and Crandell, 1959, p. 1068). The Raritan sands yield from 200 to 2,000 gallons a minute in wells on Long Island (Perlmutter and Crandell, 1959, p. 1069, 1072), which suggests excellent porosity and permeability. The shallow Tertiary sandstones and limestones, particularly those of Upper Eocene, Oligocene, and Miocene age, yield potable water from their outcrops to the sea coast. The Ocala Limestone (upper Eocene) is an especially extensive fresh-water artesian aquifer in Florida and Georgia and is known to discharge fresh water in submarine springs off Florida, where indicated on plate 2 (Stringfield and Cooper, 1951, p. 61).

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At present, no wells have been drilled on the Atlantic Continental Shelf, so the probability of adequate reservoirs for petroleum accumulations can be judged only from the wells drilled along the coast and in the Bahama Islands. Two wells, the Standard Oil Co~~mpany~~ No. 1 Hatteras Light at Cape Hatteras, North Carolina, and the Bahama Oil Co~~mpany~~, Ltd. No. 1 Andros Island on Andros Island, B. I., are particularly significant. The first penetrated 9,878 feet of dominantly marine clastics with some thick limestone sequences; the latter penetrated 14,585 feet of marine limestone and dolomite beds. Thick sandstone reservoirs are present in the Cape Hatteras well, whereas thick porous-to-cavernous limestone and dolomite beds are reservoirs in the Andros Island well.

Hatteras Light well

The drilling and testing of the Standard Oil Co. No. 1 Hatteras Light well (well NC-14, table 1) has been reported by Spangler (1950, p. 104-108). This well penetrated ten major sandstone bodies, numerous thin sandstone beds, and a few porous limestone and dolomite beds. The major sandstone bodies, ranging from 93 to 728 feet in thickness, are present at depths of (1) 9,150-9,878 feet [Basal Upper Jurassic or Lower Cretaceous (Neocomian) age], (2) 8,585-8,750 feet [Lower Cretaceous, Trinity(?) age], (3) 8,240-8,500 feet [Lower Cretaceous, Trinity(?) age], (4) 7,665-7,758 feet [Lower Cretaceous, Trinity(?) age], (5), 7,018-7,360 feet [Lower Cretaceous, Fredericksburg(?) age], (6) 6,475-6,585 feet [Lower Cretaceous, Washita(?) age], (7) 4,800-5,580 feet [Upper Cretaceous, Woodbine age], (8) 3,660-4,288 feet [Upper Cretaceous, Austin age], (9) 2,385-2,755 feet [Tertiary, lower Eocene age], and (10) 575-995 feet [Tertiary, Miocene age]. The three most promising reservoirs for petroleum -- sandstones of Fredericksburg(?), Washita(?), and Austin age -- were cored and tested. The porosity and permeability determinations are given in table 4, which is adapted from Spangler (1950, p. 107).

Table 4 near here

Table 4 - Porosity and permeability determinations for reservoirs in the Standard Oil Company No. 1 Hatteras Light well

Age of rocks	Core No.	Depth (Feet)	Recovery (Feet)	Porosity (Percent)	Permeability (Millidarcys)
Upper Cretaceous	51	3,657-66	1.5	41.2	Undet.
Austin	52	3,693-3,703	3	27.6	5.7
(Sandstone)	53t	3,827-37	3	31.8	4.5
	53b	3,827-37	3	15.9	5.7
	54	3,930-40	0.8	39.2	Undet.
	55	4,042-52	4.5	32.2	5.0
	56	4,152-62	10	40.9	Undet.
	57	4,275-85	4	28.0	5.4
Lower Cretaceous	77	6,487-97	10	27.0	65.0
Washita	77	6,487-97	10	33.7	73.6
(Sandstone)	77	6,487-97	10	33.2	70.0
	78	6,497-6,507	9	24.7	Undet.
	78	6,497-6,507	9	30.2	184
	78	6,497-6,507	9	3.1	0
	79	6,507-12	5	27.2	58.3
	79	6,507-12	5	26.9	Undet.
	80	6,512-22	7.5	29.3	Undet.
	80	6,512-22	7.5	27.8	Undet.
	80	6,512-22	7.5	32.1	Undet.
	81	6,522-32	4	19.8	118
	81	6,522-32	4	25.9	191
	82	6,532-42	3	27.8	247
	83	6,542-52	7	28.9	1,546
	84	6,552-62	10	26.4	999
	84	6,552-62	10	33.6	Undet.
	84	6,552-62	10	33.9	2,103
	85	6,562-72	10	28.0	142
	85	6,562-72	10	31.4	1,024
	86	6,572-81	7	30.8	605
	86	6,572-81	7	2.5	0
Lower Cretaceous	91	7,021-26	2.1	32.6	2,080
Fredericksburg	92	7,034-39	2.7	31.4	Undet.
(Sandstone)	93	7,076-81	4	22.0	58.3
	94	7,081-91	4	19.3	391
	94	7,081-91	4	16.5	11.7
	95	7,091-96	2.5	24.1	Undet.
	96	7,096-7,106	10	27.3	301
	96	7,096-7,106	10	29.1	537
	97	7,106-7,113	7	28.4	386
	98	7,113-23	9	29.0	810
	98	7,113-23	9	31.5	943
	99	7,123-33	10	26.8	205
	99	7,123-33	10	12.8	2.1
	100	7,191-7,201	10	25.4	Undet.
	100	7,191-7,201	10	26.1	Undet.

The principal potential petroleum reservoir of Fredericksburg age, 7,018 to 7,360 feet in depth, consists mainly of light-gray, fine-to coarse-grained sandstone, with some thin beds of light-gray, fine-grained, silty sandstone and white, slightly oolitic, finely-crystalline limestone. The upper part, 7,018 to 7,201 feet in depth, was cored and tested. The porosities range from 12.8 to 32.6 percent and the permeabilities from 2.1 to 2,080 millidarcys (table 4). A drill-stem test (No. 2, pl. 12) taken opposite the interval between 7,018 and 7,027 feet with the tool open 10 minutes recorded a bottom-hole pressure of 3,100 pounds per square inch and yielded seven barrels of mud and muddy salt water, and 51 barrels of salt water. The analysis of water from this test is given below:

	Parts per million
Sodium	42,858
Calcium	5,856
Magnesium	1,258
Sulphate	840
Chloride	79,460
Bicarbonates	47
Carbonates	0

The principal potential petroleum reservoir of Washita age, 6,487 to 6,581 feet in depth, is a 96-foot sequence of sandstone beds grading from medium grained at the top to fine grained and silty at the bottom. The porosities of these beds range from 2.5 to 33.9 percent and the permeabilities from 0 to 2,103 millidarcys. A drill-stem test (No. 1, pl. 12) with packers set at 6,474 and 6,483 feet and the tool open ten minutes recovered six barrels of mud and muddy salt water, and 55 barrels of salt water. Total depth was 6,512 feet during the test and the bottom-hole pressure was recorded as 2,900 pounds per square inch. The analysis of water from this test is given below:

	Parts per million
Sodium	36,097
Calcium	7,100
Magnesium	1,302
Sulphate	840
Chloride	71,335
Bicarbonates	99
Carbonates	0

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Rocks of Woodbine age, which include the more or less equivalent Atkinson, Tuscaloosa, and Raritan fresh-water aquifers of the Coastal Plain, have poor reservoir characteristics in the Hatteras Light well. This interval is made up of thin, silty, fine-grained sandstones interbedded with sandy shale and a few fossiliferous limestone layers. Updip in the Standard Oil Co. No. 2 North Carolina Esso well (well NC-7) in Pamlico Sound, the interval is about the same thickness, roughly 1,300 feet, but consists of thick sandstone beds interbedded with thin layers of gray shale and some limestone lenses. Generally, the sandstone beds are very fine-to medium-grained, limy, and slightly carbonaceous with scattered conglomeratic layers composed mostly of chert and pebbles. Examination of a core between depths of 4,377 and 4,387 feet revealed a fine-to medium-grained, slightly limy, glauconitic sandstone that is extremely porous. This comparison suggests that rocks of Woodbine age may be considerably less porous and permeable a short distance offshore than they are beneath the Atlantic Coastal Plain. Such a condition is not necessarily a negative factor in the evaluation of the petroleum potential of the Shelf, as clean, well-sorted sandstones are not common among the oil reservoirs in the United States.

The principal potential petroleum reservoir of Austin age, 3,660 to 4,288 feet in depth, is composed of fine-to coarse-grained, calcareous glauconitic sandstone with thin conglomeratic layers. Some coarse sandstones are very loosely cemented and the individual sand grains break free in the drilling. Porosities range from 15.9 to 40.9 percent and permeabilities from 4.5 to 5.7 millidarcys (table 4). Drill stem tests were not made in this interval.

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The possibility of carbonate reservoirs beneath the Shelf in the vicinity of the Hatteras Light well is suggested by porous zones in limestone and dolomite beds in pre-Upper Cretaceous rocks. The upper part of a 100-foot carbonate sequence at the top of rocks of Upper Jurassic or Lower Cretaceous (Neocomian) age (8,750 feet) contains oolitic limestone, conglomeratic limestone, dolomitic limestone, porous granular dolomite, and anhydrite. The porosity of these beds is slight compared to the sandstones discussed previously, but it bears on the probability that thicker units of porous dolomite and oolitic limestone beds may be expected offshore. Another porous carbonate bed was drilled in the lower part of rocks of Trinity (?) age between depths of 8500 and 8585 feet. This one is composed of light-brown, sandy, coarsely crystalline dolomite and dolomitic limestone. The upper part was described as cavernous by Swain (1952, p. 66). No drill-stem tests or porosity tests were made for this interval.

Andros Island well

The Bahamas Oil Co., Ltd. No. 1 Andros Island well (well BA-2) in the Bahama Islands penetrated 14,585 feet of carbonate rocks ranging from Lower Cretaceous to Tertiary in age. This sequence included many porous, fragmental and fossiliferous limestones in differing stages of recrystallization and dolomitization. Circulation of drilling mud was lost at depths of 70, 540, 2,689, 9,604, 10,020, 12,965, 13,230, and 13,383 feet before the drill pipe was lost in the hole at a depth of 14,585 feet. The well was abandoned at that depth with 11,960 feet of drill pipe not recovered. Especially viscous muds with fibre added were used to regain circulation. Cavities were reported by the driller at 10,663-685, 10,687-696, 12,963-965, 13,202-206, 13,208-210, 13,214-215, 13,225-230, and 13,312-313 feet; all of which are in early Upper Cretaceous and late Lower Cretaceous rocks. Sample and core studies indicate considerable fracture and intergranular porosity in the rocks as well as cavernous porosity. Carbonate reservoirs are so thick and open as to create drilling problems in this area, but more suitable conditions may be present at other places beneath the Continental Shelf in the Bahama and Blake Plateau regions.

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Traps

Traps for petroleum have been grouped by Levorsen (1954, p. 142-143) into three basic types; (1) structural traps, (2) stratigraphic traps, and (3) combination traps.

(1) Structural traps are those that have been formed primarily by local deformation of the reservoir and sealing beds. The deformation may involve either folding or faulting, or both, and sometimes produces fracturing of the reservoir as an important element of the trap.

(2) Stratigraphic traps are those that have been formed primarily by stratigraphic variations and discontinuities. Primary stratigraphic traps are those that are effective mainly because of original depositional characteristics, such as composition, shape, and attitude of the reservoir. These are related mainly to lateral variations of lithology, or lithofacies in the broadest sense of that term. Secondary stratigraphic traps are those that are effective primarily because of discontinuities in stratigraphic succession. Such traps may be associated with either local unconformities present in a few townships or regional unconformities present throughout a sedimentary basin or province.

(3) Combination traps are those that combine both structural and stratigraphic elements of subequal importance. Combinations of unconformities and anticlines with different modifications due to faults, lithofacies, and hydrodynamic conditions are probably the most common.

This general classification is based on the relative importance of the different geological components of the trap. These components are sealing beds, folds and faults, unconformities, lithofacies, and hydrodynamic conditions. The following discussion attempts to identify each component in the Mesozoic rocks along the Atlantic Coast and suggest areas in which certain combinations of components may have formed traps for petroleum.

Sealing beds

Sealing beds of some kind are necessary for the entrapment of petroleum, except in traps sealed with asphaltic residue and any possibly created by hydrodynamic conditions alone. The sealing beds are usually the more plastic beds of clay, shale, and salt, but also may be anhydrite, limestone, and dolomite beds that have escaped fracturing or whose fractures have been closed by chemical precipitates.

Clay and shale beds act as aquacludes in the artesian system of the Coastal Plain north of Florida, and could serve readily as sealing beds over petroleum accumulations. Some that extend seaward an unknown distance beneath the Shelf, judging by the Hatteras Light (well NC-14) in North Carolina, include shale beds of Trinity(?) or Fredericksburg(?) age, of Eagle Ford age, of Taylor and Navarro age, and of Paleocene age.

Anhydrite, which is not only a cap rock in salt-dome fields but also a common seal throughout the World in oil fields with carbonate reservoirs, overlies the oil-producing Sunniland Limestone of Lower Cretaceous Trinity(?) age in the oil fields of southern Florida. This unit has been called informally the "upper anhydrite" by oil geologists of this area. A short distance below the oil-producing beds is a massive anhydrite bed once referred to as the "lower massive anhydrite" and now known as the Punta Gorda anhydrite (Applin and Applin, 1965, p. 39). Thinner beds of anhydrite are interspersed with limestone and shale in other parts of the Lower Cretaceous rocks, in the late Upper Cretaceous rocks, and in the early Tertiary rocks (Cedar Keys Limestone of Paleocene age and Oldsmar Limestone of Eocene age). Similar lithologies are present in southern Florida wells and have been reported orally in the deep well on Cay Sal (well 1, table 1) about 80 miles southeast of the Florida Keys.

Massive anhydrite beds were not found in the Andros Island well (well BA-2, table 1) in the Bahamas, and only a few thin anhydrite beds have been reported along the Atlantic Coast in the vicinity of Cape Hatteras (Spangler, 1950, p. 123; Swain, 1952, p. 66 and 67). This suggests that conditions suitable for deposition of evaporites may have been more prevalent in the eastern Gulf of Mexico than northward along the Atlantic Coast. In general, however, it seems that sealing beds of clay, shale, and impervious chemical precipitates may be common enough beneath the Atlantic Continental Shelf to provide the vertical discontinuities necessary for trapping petroleum.

Folds and faults

Although the Coastal Plain deposits flank the much-folded and faulted Appalachian Mountains, they have not been involved in any major tectonic movements. As a result, they do not exhibit the abrupt folds and numerous faults commonly associated with the flanks of mountain systems. This suggests that few traps of a purely structural nature should be expected. Nevertheless, the basement structural features buried by Coastal Plain deposits are reflected to different degrees by gentle warping and normal faulting in the younger rocks, and these gentle folds and faults, along with stratigraphic components, may be sufficient to provide combination traps.

The major positive features are the Cape Fear arch, the Peninsular arch, the Bahama uplift, and a long basement ridge at the Shelf edge off New England (see pl. 4). Both the Cape Fear arch and the Peninsular arch (including the offsetting Ocala arch) show evidence of recurrent movement along older lines of weakness and an overlap of Lower Cretaceous beds by Upper Cretaceous beds. The Bahama uplift, as far as known from published data, is still in the category of a logical, but unproved, structural inference. If the inference is valid, a thick marine sequence favorable to the generation of petroleum has been involved in warping and faulting, possibly with reef growth, that may have created traps for petroleum. The long ridge at the edge of the Continental Shelf off New England (pl. 4) is completely unknown except for its expression in the basement rocks as recorded by seismic surveys. Whether or not this basement ridge is reflected in sedimentary rocks of suitable character for petroleum accumulation cannot be surmised at present.

Several long faults or fault zones along the edge of the Continental Shelf and along the continental margin at the eastern edge of the Blake Plateau have been suggested by Pressler (1947, fig. 1, p. 1858). The presence and placement of these faults, inferred from bottom topography, are highly speculative, as little seismic evidence for or against their existence has been presented. Sheridan, Drake, Nafe, and Hennion (1964, p. 183) reported recent seismic profiles off Florida and off Georgia favor some faulting at the edge of the Shelf, but the amount and direction is uncertain. Recent investigations of Tertiary strata off Jacksonville, Florida (JOIDES, 1965), do not indicate the presence of a post-Cretaceous fault along the Shelf edge there, but no information is available on the older beds.

A transcurrent fault in the basement beneath the Shelf has been postulated along the 40th parallel about 50 miles south of New York by Drake, Heirtzler, and Hirshman (1963, p. 5270) on the basis of a linear magnetic anomaly (see fig. 6). Emery (1965, p. C159, and fig. 1) has suggested that suitable petroleum-bearing structures may be associated with this "major strike-slip fault." No data suggesting the time of the major fault movements or the presence of smaller associated structures has been published.

Lithofacies

Lateral variations in lithology within a stratigraphic unit that may form primary stratigraphic or combination traps are difficult to predict in relatively unexplored regions such as the Atlantic Coastal Plain and Continental Shelf. Such traps may include offshore bars, channel fillings, reefs, and porosity changes between two carbonate facies or carbonate and clastic facies. Offshore bars and channel fillings might be expected in dominantly shale and marl sequences of Upper Cretaceous age along the Coastal Plain north of Florida. Reefs and porosity changes at dolomite-limestone transitions may be present in Florida and along the Continental Shelf, particularly beneath the Bahama and Blake Plateau platforms. Limestone-shale and sandstone-limestone transitions probably are present beneath the Shelf at many places. One of the likely places is the Southeast Georgia embayment. There Coastal Plain well data are adequate to show a clastic-carbonate transition in Cretaceous rocks trending northeasterly across the inner Shelf. This in conjunction with faults or folds offers possibilities for combination traps.

Unconformities

Numerous unconformities subdivide the Coastal Plain deposits, but only a few extend far enough downdip and laterally to be important as avenues of migration or loci of hydrocarbon traps. However, these few have provided excellent opportunities for the accumulation of petroleum in both secondary stratigraphic and combination traps.

Little is known of the nature of possible unconformities separating sequences assigned to Upper Jurassic or Lower Cretaceous (Neocomian), Trinity(?), Fredericksburg(?), and Washita(?) ages, as only a few wells at the coastal extremities have been drilled this deep. These rocks do wedge out against the Peninsular arch (pls. 9, 15), the Cape Fear arch (pls. 9, 12), and northward from New Jersey (pl. 9). They may wedge out landward beneath the Continental Shelf all along the coast similar to the way they do west of the Hatteras Light well (well NC-14, pl. 12).

Probably the most important unconformity occurs at the top of the beds of Washita(?) age, essentially the top of the Lower Cretaceous rocks. The structure of the Lower Cretaceous rocks is somewhat different from that of the overlying beds. The marine Lower Cretaceous rocks not only lap out landward against the basement rocks but are overlapped by Upper Cretaceous (Woodbine) reservoirs as indicated in plates 9, 11, and 12. One of the places where this unconformity and others within Lower Cretaceous and older beds may supply the component necessary for a combination trap is on the seaward nose of the Cape Fear arch.

The unconformity at the top of the Cretaceous rocks probably is less important as a trapping component than the deeper major ones. Thinning of Upper Cretaceous rocks and overlap by Tertiary beds as exemplified in Georgia on plate ~~12~~ 13 takes place at relatively shallow depths and rather close to the outcrops. Possibly it could be a more important factor on structures beneath the Continental Shelf.

Hydrodynamic conditions

The accumulation of petroleum in all traps may be modified considerably by the hydrostatic or hydrodynamic forces of the water in the reservoir (Hubbert, 1953, p. 1954-2026). Under hydrostatic conditions, the water is essentially at rest and the impelling force on the petroleum is upward. The boundaries of the trap alone determine the location and shape of the accumulation. Under hydrodynamic conditions, a potential exists from areas of higher pressure to those of lower pressure and this force modifies the location and shape of the accumulation by inclining it in the direction of flow. The effect of hydrodynamics may be sufficient to cause trapping in or near lithologic, depositional, and structural features that would be ineffective under hydrostatic conditions.

Fresh-water reservoirs beneath the Coastal Plain alluvium are under artesian pressure downdip from their outcrops, and flowing wells are not uncommon in lower areas. The artesian head of fresh water in the Ocala Limestone (Eocene) beneath the Shelf is as much as 30 feet at a distance of 27 miles off Jacksonville, Florida (JOIDES, 1965, p. 710; Schlee and Gerard, 1965, p. 37). Submarine springs of large volume issue from the Ocala Limestone through sink holes near the shore in the same area (Stringfield and Cooper, 1951; Stringfield, 1964, written commun.).

Although water-level and pressure records are available for many wells in the fresh-water part of the reservoirs, little is known about pressures where the waters become brackish or salty at depth. The one deep well for which drill-stem test pressures have been published is the Hatteras Light well (well NC-14, pl. 12) in North Carolina. In this well, drill-stem tests opposite intervals from 6,474 to 6,583 and 7,018 to 7,027 feet in depth recorded bottom-hole pressures of 2,900 and 3,100 pounds per square inch respectively. The reservoirs tested are Lower Cretaceous sandstones of Washita(?) and Fredericksburg(?) age that do not crop out along the Fall Line in North Carolina because of Upper Cretaceous and Tertiary overlap. These recorded bottom-hole pressures, which may not be very accurate because of the difficulties in setting packers tightly above and below the interval tested, are equivalent to a head of 6,670 and 7,130 feet respectively. These approximate the hydrostatic head of the reservoirs at depths of 6,583 and 7,027 feet plus the land elevation (80 feet) at the Cretaceous outcrop more than 100 miles westward, and suggest that only gentle pressure gradients exist in these reservoirs in this area. Until many more drill-stem tests are available, little can be done to determine the regional effects of hydrodynamics.

Summation of petroleum potential

Pre-Cretaceous rocks have few characteristics of petroleum-producing beds. Paleozoic rocks in the pre-Mesozoic basement are highly metamorphosed except in southwestern Georgia (pl. 14) and central Florida (pls. 9 and 15), where they are not metamorphosed but so highly indurated and folded as to have doubtful reservoir characteristics. Triassic(?) rocks (pls. 11 and 14) exhibit many continental aspects, such as red beds and conglomerate, and numerous igneous intrusions, which are not generally regarded as indicative of good source rocks.

Lower Cretaceous rocks and those classed tentatively as Upper Jurassic or Lower Cretaceous (Neocomian) in age in this report (pls. 12 and 16) offer the most promising prospects for oil and gas production in the Atlantic coastal region. Their combined thickness probably exceeds 5,000 feet beneath the Continental Shelf in the Baltimore Canyon trough and in the Southeast Georgia embayment. Even greater thicknesses may exist beneath the Blake Plateau and Bahama Islands. These rocks, where penetrated along the coastal extremities, exhibit many characteristics of petroleum-producing beds. Marine beds generally regarded as potential sources of petroleum are predominant, and the environment of their deposition, at least in the southern areas, probably favored reef growth. Thick, very porous, salt-water bearing reservoirs, both sandstone and carbonate, are numerous. Although not many thick shale beds have been drilled in the sequence as yet, adequate sealing beds may be provided by dense limestone and anhydrite beds. The structural attitude of these rocks is considerably different from that of the Upper Cretaceous (Woodbine) rocks that overlap them. Important unconformities are present not only at the top but within the sequence. These suggest the possibility of not only structural but combined structural and stratigraphic traps.

Rocks of Upper Cretaceous age have good possibilities for oil and gas production beneath the Continental Shelf, but only fair possibilities, chiefly for gas, in the Coastal Plain. Although the thickness of these rocks does not exceed 3,500 feet onshore and may be only a few thousand feet more beneath the Shelf (pl. 18), the beds are buried sufficiently beneath the Tertiary rocks to provide ample opportunity for the accumulation of petroleum. Reservoir rocks are thick and numerous in the Upper Cretaceous rocks of the Coastal Plain and seem to extend beneath the Shelf where thick marine source rocks may be expected. Rocks of Woodbine and Eagle Ford age appear to be a favorable reservoir-source rock combination whose thickness probably exceeds 2,000 feet offshore (pl. 19). Unconformities at the top and base are extensive; the basal unconformity may be the more important from the standpoint of petroleum accumulation, as it permits the basal Upper Cretaceous sandstones of Woodbine age to overlap the underlying, more marine Lower Cretaceous rocks. Depending upon the juxtaposition of lithologies, this unconformity may be either a trap or an avenue of migration in different places. It appears to mark an extremely porous zone in the carbonates of the Andros Island well.

Tertiary rocks exhibit very good reservoir and fair source rock characteristics. They are less promising than Cretaceous rocks for a number of reasons (1) they probably are less than 4,000 feet thick in most of the area north of southern Florida and the Bahama Islands (pl. ~~19~~ 20), and contain fresh-to-brackish artesian water in much of that area; (2) they crop out in part along the Shelf and Blake Plateau (see pl. 2 and figs. 7 and 8), and in other places give rise to submarine springs in sink holes (Stringfield and Cooper, 1951, p. 61); (3) structural features are reflected less distinctly in the Tertiary rocks than in the older rocks, as they have been subject to less tectonic adjustment; (4) unconformities within the Tertiary rocks are less significant regionally than those in older rocks. Tertiary (Paleocene and lower Eocene) beds at the basal unconformity wedge out against Upper Cretaceous rocks in places (pl. 18). However, this wedge-out occurs at depths too shallow to offer much hope for trapping commercial quantities of petroleum.

The Continental Shelf offers more promise as a potential petroleum province than the Coastal Plain because it has a thicker sedimentary column with better source beds and trapping possibilities. Thicknesses of 10,000 feet and more are present beneath the Coastal Plain only in southern Florida, whereas thicknesses beneath the Continental Shelf exceed 10,000 feet in the Southeast Georgia embayment and Georges Bank trough, 12,500 feet in the Emerald Bank basin, and 15,000 feet in the Baltimore Canyon trough (pl. 4). Comparable thicknesses may be present beyond the Shelf beneath the Blake Plateau and Bahama platform. Extreme thicknesses of 25,000 feet underlie the continental slope in water 5,000 to 10,000 feet deep, not within present economic limits for commercial exploration.

Different views as to the most favorable areas of the Shelf for petroleum exploration have been expressed by Pepper (1958, p. 51, 52, and 55), Johnston, Trumbull, and Eaton (1959, p. 439-441, Richards (1963, p. 150, 151), and Emery (1965, fig. 6). These are based mainly on considerations of basement structure and gross thickness of sediments without regard to age or unconformities.

According to Pepper (1958, p. 55), the results of an airborne magnetometer survey of the Bahamas "are said to indicate that structures are present which may be favorable for the accumulation of oil". He points out favorable thicknesses of sediments at places only 60 miles offshore between Florida and New Jersey, but states (p. 51, 52) rather flatly that "the possibility of finding oil in commercial quantities in any of the shelf areas between New Jersey and Newfoundland is not considered to be favorable." Later writers, including this one, do not agree with this evaluation of the Shelf north of New Jersey.

In discussing structural factors related to petroleum possibilities, Johnston, Trumbull, and Eaton (1959, p. 440, 441) give favorable mention to the Cape Fear arch and its seaward extension, a high at Fort Munroe, Virginia, and the basement ridge mapped at the Shelf edge off New England by Drake, Ewing, and Sutton (1959, p. 176, fig. 29). Somewhat earlier, a brackish ground-water anomaly on the Cape Fear arch, a few miles inland from Wilmington, had been cited by LeGrand (1955, p. 2020) as deserving attention "if oil-prospecting becomes more active on the Atlantic Coast".

Richards (1963, p. 151, 152) in discussing the oil prospects offshore New Jersey mentioned Five Fathom Bank, about 10 miles off Cape May, and several landward shoals as likely places for an oil test. These locations were selected for their convenience in drilling operations rather than for geological considerations of a local nature.

Most recently, Emery (1965, p. C159, and fig. 1) has stated that suitable petroleum-bearing structures may be associated with the seaward extension of the Cape Fear arch, the basement ridge at the Shelf edge off New England, and a "major strike-slip fault" just southeast of New York City. The latter is the transverse fault deduced by Drake, Heirtzler, and Hirshman (1963, p. 5270) from magnetic anomalies in the basement rocks (see pl. 8).

All the published suggestions for areas in which to conduct exploration operations for petroleum seem to have merit. However, the Bahama platform, the seaward extension of the Cape Fear arch, the long basement ridge at the Shelf edge off New England, and the Southeast Georgia embayment appear to this writer to be the most favorable areas for initial operations in waters controlled by the United States. The outer Shelf in Canadian waters off Nova Scotia and Newfoundland offers just as good possibilities but, with the exception of the possible extension of the outer Shelf basement ridge near Sable Island, no basis exists for comparing different parts of this huge area that includes the Grand Banks extending 120 miles from land.

In summary, more stratigraphic and seismic data on the older rocks are needed before additional areas for exploration are suggested. However, the probabilities for discovery of commercial accumulations of petroleum in the Atlantic coastal region seem to favor rocks classed herein as Upper Jurassic or Lower Cretaceous (Neocomian), and Lower Cretaceous in stratigraphic or combination traps beneath the Continental Shelf.

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TABLE 1. -- RECORDS OF SELECTED WELLS ALONG THE ATLANTIC COAST

ALABAMA

No.	Well name	Location	Alt.	Total depth	Oldest rocks reported	Notes
AL-1	Capital Oil & Gas Co. No. 1 Gholston	Sec. 18, T. 14N., R. 22E. Bullock Co.	310	1725	Pre-Mesozoic	Electric log available Top of pre-Mesozoic granite 1700 ft.
AL-2	Capital Oil & Gas Co. No. 1 Pickett	Sec. 22, T. 13N., R. 21E. Bullock Co.	430	2523	Pre-Mesozoic	Electric log available Top of pre-Mesozoic granite 2495 ft.
AL-3	W. B. Hinton No. 1 Creel	Sec. 14, T. 9N., R. 26E Barbour Co.	504	5546	Triassic(?) or pre-Mesozoic	Electric log available Top of pre-Cretaceous rocks 4395 ft.

BAHAMAS

No.	Well name	Location	Alt.	Total depth	Oldest rocks reported	Notes
BA-1	Bahama California Oil Co. No. 1 Cay Sal 4	Lat 23°49'24" N., long 80°12'24" W.		18906		Offshore No data released, May, 1966
BA-2	Bahama Oil Co., Ltd. No. 1 Andros Island	Lat. 24°52'37.2" N.; long. 78°01' 54.7" W., Stafford Creek, Andros Island	20	14585	Lower Cretaceous	Electric log from 6503 to 10670 ft. only
BA-3	Harrisville Co. No. 2 Eleuthera Island	Hatchet Bay, approx. lat 25° 20'45" N.; long 76°28'30" W., Eleuthera Island	123	730	Miocene (?) ~~dolomite~~	No electric log available Tested salt water 200-490 ft. in Miocene. Water level 123 ft. below surface.

DELAWARE

No.	Well name	Location	Alt.	Total depth	Oldest rocks reported	Notes
DL-1	C. R. Casson No. 1 Water Well	About 4.5 mi. NW of Newcastle on Hy. 41, Newcastle Co.	65	365	Pre-Mesozoic	Top of crystalline rock 352 ft.
DL-2	U. S. Army Fort Dupont Water Well	Near Delaware City Newcastle Co.	10	762	Lower Cretaceous	
DL-3	Town of Middletown Water Well	Middletown Newcastle Co.	65	1478	Pre-Mesozoic(?)	Probably reached bedrock at total depth
DL-4	Deakyneville N. 1 Test Well	About 1.5 mi. NE of Smyrna Newcastle Co.		2312	Pre-Mesozoic	Top of pre-Mesozoic rocks 2290 ft.
DL-5	U. S. Air Force Base No. JE 32-4 Test Well	Near Dover Kent Co.	27	1422	Upper Cretaceous	
DL-6	Town of Lewes Water Well	Lewes Sussex Co.	10	1080	Miocene	
DL-7	Sun Oil Co. No. D-6 Townsend (Apple Orchard)	4 mi. SE of Bridgeville Sussex Co.	43	2600	Upper Cretaceous	Electric log available
DL-8	Continental Oil Co. No. 1 Townsend	4 mi. SE of Bridgeville Sussex Co.	42	3012	Upper Cretaceous	
DL-9	Sun Oil Co. No. 1 R. Russell	5.2 mi. SE of Bridgeville Sussex Co.	36	2674	Upper Cretaceous	

FLORIDA

No.	Well name	Location	Alt.	Total depth	Oldest Rocks reported	Notes
FL-1	Jeffreys No. 1 Abbott	Sec. 19, T. 3 N., R. 32 W., Escambia Co.	202	7513	Lower Cretaceous	Electric log available
FL-2	Zach Brooks Drilling Co. No. 1 Caldwell-Garvin Unit	Sec. 31, T. 2 S., R. 31 W., Escambia Co.	33	12512	Lower Cretaceous	Electric log available
FL-3	Mobil Oil Co. No. 1 St. Regis Paper	Sec. 35, T. 4 N., R. 30 W., Santa Rosa Co.	120	12523	Lower Cretaceous	Electric log available
FL-4	Sunnyland Oil Co. No. 1 Nowling	Sec. 24, T. 5 N., R. 29 W., Santa Rosa Co.	250	6665	Lower ~~Upper or Lower~~ Cretaceous (?)	Electric log available
FL-5	Humble Oil & Refining Co. No. 1 F. S. L. 833	Sec. 17, T. 2 S., R. 28 W., Pensacola Bay, Santa Rosa Co.	26	7505	Lower Cretaceous	Electric log available
FL-6	Sinclair Oil & Gas Co. No. 1 Boland	Sec. 7, T. 1 N., R. 27 W., Santa Rosa Co.	35	6950	Lower Cretaceous(?)	Electric log available
FL-7	Haden No. 1 McCort	Sec. 30?, T. 4 N., R. 24 W., Okaloosa Co.	254?	6326	Lower ~~Upper or Lower~~ Cretaceous	Electric log available
FL-8	Hawkins No. 1 Kelly	Sec. 18, T. 2 S., R. 22 W., Cobbs Point, Okaloosa Co.	27	6250	Lower Cretaceous	No electric log available
FL-9	Hawkins No. 1 Coffeein	Sec. 12, T. 2 S., R. 21 W., Fourmile Point, Walton Co.	14	6010	Lower Cretaceous	No electric log available
FL-10	Sun Oil Co. No. 4 Belcher	Sec. 25, T. 4 N., R. 21 W. Walton Co.	244	5220	Lower Cretaceous	Electric log available
FL-11	Pan American Petroleum Corp. No. 1 Sealy	Sec. 9, T. 1 S., R. 18 W., Walton Co.	111	11947	Pre-Mesozoic ~~Lower Cretaceous~~	Electric log available Top of pre-Mesozoic rhyolite 11930 ft.

FLORIDA

No.	Well name	Location	Alt.	Total Depth	Oldest Rocks Reported	Notes
FL-12	Byers Oil Co. No. 1 Sealey	Sec. 12, T. 2 S., R. 18 W., Walton Co.	37	5475	Lower Cretaceous	Electric log available
FL-13	Hunt Oil Co. No. 1 Linton	Sec. 30, T. 3 N., R. 17 W., Walton County	104	6503	Lower Cretaceous	Electric log available
FL-14	Southeastern Exploration Co. No. 1 Hobbs-Gillis	Sec. 18, T. 6 N., R. 17 W., Holmes Co.	159	8521	Lower Cretaceous	Electric log available
FL-15	Breeding No. 1 Coats	Sec. 25, T. 7 N., R. 15 W., Holmes Co.	202	4107	Lower Cretaceous	Electric log available
FL-16	Magnolia Petroleum Co. No. 1 State Block 4 B	Sec. 21, T. 3 S., R. 15 W., Bay Co.	7	7003	Lower Cretaceous	Electric log available
FL-17	Temple Oil Co. No. 1 Moore	Sec. 27, T. 1 S., R. 15 W., Bay Co.	60	6021	Lower Cretaceous	Electric log available
FL-18	Chipley Oil & Gas Co. No. 1 Dekle	Sec. 27, T. 4 N., R. 13 W., Washington Co.	198	4912	Lower Cretaceous	No electric log run
FL-19	Humble Oil & Refining Co. No. 1 Tindel	Sec. 8, T. 5 N., R. 11 W., Jackson Co.	128	9245	Paleozoic ~~sandstone and shale~~	Electric log available Top of Paleozoic ~~rocks~~ sandstone and shale 8440 ft.
FL-20	Hammond No. 1 Granberry	Sec. 15, T. 5 N., R. 9 W., Jackson Co.	107	5022	Triassic (?) ~~red beds~~	No electric log run
FL-21	Pure Oil Co. No. 2 International Paper Co.	Sec. 31, T. 1 S., R. 10 W., Calhoun Co.	107	5096	Lower Cretaceous	Electric log available
FL-21A	Gulf Coast Drlg and Explor. Co. No. 1 U.S.A.	Sec. 4, T. 5 S., R. 7 W., Liberty Co.	49	10,011	Lower Cretaceous	Electric log available

FLORIDA

No.	Well name	Location	Alt.	Total Depth	Oldest Rocks Reported	Notes
FL-22	Pure Oil Co. No. 1 Hopkins	Sec. 22, T. 6 S., R. 9 W., Gulf Co.	32	8708	Lower Cretaceous	Electric log available
FL-23	Magnolia Petroleum Co. No. 1-A ~~5-B~~ State Blk. 5-B	Lat 29°41'18"N., long 85°07'13"W. ~~Sec. 2, T. 9 S., R. 9 W.,~~ Franklin Co.	10	7021	Lower Cretaceous	Electric log available
FL-24	California Co. No. 1 F. S. L. 224-A	Sec. 7, T. 9 S., R. 5 W., St. George Sound, Franklin Co.	26	7031	Lower Cretaceous	Offshore Electric log available
FL-25	California Co. No. 2 F. S. L. 224-A	Lat 29°47'03" N.; long 84°22'51" W., Franklin Co.	35	10566	Lower Cretaceous	Offshore Electric log available
FL-26	Pure Oil Co. No. 2 St. Joe Paper	Sec. 35, T. 6 S., R. 4 W., Franklin Co.	21	4787	Lower Cretaceous	Electric log available
FL-27	Hughes Oil Co. No. 1 McDonald	Sec. 6, T. 2 N., R. 5 W., Gadsden Co.	296	4222	Lower Cretaceous	Electric log available
FL-28	Oles-Nayler No. 1 Florida Power	Sec. ~~26~~ 35, T. 2 N., R. 3 W., Gadsden Co.	177	4240	Lower Cretaceous	Electric log available
FL-29	Central Florida Oil & Gas Co. No. 1 Rhodes	Sec. 11, T. 2 S., R. 1 E., Leon Co.	50	3755	Upper Cretaceous	No electric log run
FL-30	Ravelin-Brown No. 1 Philips	Sec. 14, T. 3 S., R. 1 E., Wakulla Co.	28	5766	Triassic (?) ~~red beds~~	Electric log available
FL-31	Coastal Petroleum Co. No. 1 Larsh	Sec. 1, T. 2 S., R. 3 E., Jefferson Co.	51	7913	Triassic (?) ~~red beds and sills~~	Electric log available Top of Triassic (?) red beds and sills rocks 7909 ft.

FLORIDA

No.	Well name	Location	Alt.	Total Depth	Oldest Rocks Reported	Notes
FL-32	South State Oil Co. No. 1 Miller & Gossard	Sec. 17, T. 2 N., R. 5 E., Jefferson Co.	220	3838	Upper Cretaceous	No electric log available
FL-33	Hunt Oil Co. No. 2 Gibson	Sec. 6, T. 1 S., R. 10 E., Madison Co.	107	5385	Paleozoic ~~black shale~~	Electric log available Top of igneous rock 4589 ft. Top of Paleozoic black shale 4628 ft.
FL-34	Humble Oil & Refining Co. No. 1 Hodges	Sec. 12, T. 5S., R. 6 E., Taylor Co.	36	6254	Triassic (?) ~~diabase gabbro~~	Electric log available Top of Triassic (?) diabase gabbro 6153 ft.
FL-35	Gulf Oil Corp. Brooks-Scanlon No. 1 Block 33	Sec. 18, T. 4 S., R. 9 E., Taylor Co.	96	5243	Triassic (?) ~~diabase gabbro~~	Electric log available Top of Triassic (?) ~~rocks~~ diabase gabbro 5200 ft.
FL-36	Gulf Oil Corp. Brooks-Scanlon No. 1 Block 42	Sec. 9, T. 8 S., R. 9 E., Taylor Co.	41	5517	Triassic (?) ~~diabase gabbro~~	Electric log available Top of Triassic (?) ~~rocks~~ diabase gabbro 5438 ft.
FL-37	Gulf Oil Corp. Brooks-Scanlon No. 1 Block 49	Sec. 36, T. 5 S., R. 10 E., Lafayette Co.	87	4512	Paleozoic ~~quartzitic sandstone~~	Electric log available Top of Paleozoic ~~rocks~~ quartzitic sandstone 4505 ft.
FL-38	Sun Oil Co. No. 1 Crapps	Sec. 25, T. 6 S., R. 12 E., Lafayette Co.	70	4133	Paleozoic ~~quartzitic sandstone and shale~~	Electric log available Top of Paleozoic ~~rocks~~ quartzitic sandstone and shale 4030 ft.
FL-39	Stanolind Oil & Gas Co. No. 1 Perpetual Forest, Inc.	Sec. 5, T. 11 S., R. 11 E., Dixie Co.	33	7510	Paleozoic ~~quartzitic sandstone~~	Electric log available Top of Paleozoic ~~rocks~~ quartzitic sandstone 5228 ft.
FL-40	Sun Oil Co. No. 1 Adams	Sec. 15, T. 9 S., R. 15 E., Gilchrist Co.	93	3753	Paleozoic ~~quartzitic sandstone & shale~~	Electric log available Top of Paleozoic ~~rocks~~ quartzitic sandstone and shale 3588 ft.

FLORIDA

No.	Well name	Location	Alt.	Total Depth	Oldest Rocks Reported	Notes
FL-41	Sun Oil Co. No. 1 Odom	Sec. 31, T. 5 S., R. 15 E., Suwannee Co.	73	3161	Paleozoic ~~black shale~~	Electric log available Top of Paleozoic black shale ~~rocks~~ 3040 ft.
FL-42	Fields-Randall No. 1 Crawley	Sec. 6, T. 2 S., R. 13 E., Suwannee Co.	119	3833	Paleozoic	Electric log available
FL-43	Sun Oil Co. No. 1 Tillis	Sec. 28, T. 2 S., R. 15 E., Suwannee Co.	162	3572	Paleozoic ~~black shale~~	Electric log available Top of Paleozoic black shale ~~rocks~~ 3500 ft.
FL-44	Sun Oil Co. No. 1-A Sapp	Sec. 24, T. 2 S., R. 16 E., Columbia Co.	138	3311	Paleozoic ~~black shale~~	Electric log available Top of Paleozoic black shale ~~rocks~~ 3303 ft.
FL-45	Humble Oil & Refining Co. No. 1 Cone	Sec. 22, T. 1 N., R. 17 E., Columbia Co.	141	4444	Paleozoic ~~black shale~~	Electric log available Top of Paleozoic black shale ~~rocks~~ 3482 ft.
FL-46	Hunt Oil Co. No. 1 Hunt	Sec. 21, T. 1 N., R. 20 E., Baker Co.	130	3349	Paleozoic ~~quartzitic sandstone~~	Electric log available Top of Paleozoic quartzitic sandstone ~~rocks~~ 3342 ft.
FL-47	Tidewater Associated Oil Co. No. 1 Wiggins	Sec. 15, T. 6 S., R. 20 E., Bradford Co.	141	3167	Paleozoic ~~quartzitic sandstone & shale~~	Electric log available Top of Paleozoic quartzitic sandstone and shale ~~rocks~~ 3167 ft.
FL-48	Tidewater-Associated Oil Co. No. 1 Parker	Sec. 33, T. 7 S., R. 19 E., Alachua Co.	168	3220	Paleozoic ~~quartzitic sandstone & shale~~	Electric log available Top of Paleozoic quartzitic sandstone and shale ~~rocks~~ 3170 ft.
FL-49	The Texas Co. No. 1 Creighton	Sec. 16, T. 11 S., R. 19 E., Alachua Co.	77	3527	Lower Cretaceous	Electric log available

FLORIDA

No.	Well name	Location	Alt.	Total Depth	Oldest rocks Reported	Notes
FL-50	Tidewater-Associated Oil Co. No. 1 Phifer	Sec. 24, T. 9 S., R. 21 E., Alachua Co.	132	3228	Paleozoic ~~quartzitic sandstone & shale~~	Electric log available Top of Paleozoic ~~rocks~~ quartzitic sandstone and shale 3217 ft.
FL-51	St. Mary's River Oil Corp. No. 1 Hilliard Turpentine Co.	Sec. 19, T. 4 N., R. 24 E., Nassau Co.	110	4824	Paleozoic ~~black shale & diabase~~	No electric log run Top of Paleozoic ~~rocks~~ black shale and diabase 4636 ft.
FL-52	Humble Oil & Refining Co. No. 1 Foremost Properties Corp.	Sec. 4, T. 6 S., R. 25 E., Clay County	115	5862	Paleozoic ~~quartzitic sandstone & shale~~	Electric log available Top of Paleozoic ~~rocks~~ quartzitic sandstone and shale 3725 ft.
FL-53	Sun Oil Co. No. 1-A Roberts	Sec. 19, T. 9 S., R. 25 E., Putnam Co.	206	3328	Paleozoic ~~quartzitic sandstone~~	Electric log available Top of Paleozoic ~~rocks~~ quartzitic sandstone 3320 ft.
FL-54	Sun Oil Co. No. 1 Westbury	Sec. 37, T. 11 S., R. 26 E., Putnam Co.	32	3892	Pre-Mesozoic ~~Volcanic ash & tuff~~	Electric log available Top of pre-Mesozoic ~~rocks~~ volcanic rocks 3873 ft.
FL-55	Humble Oil & Refining Co. No. 1 Campbell	Sec. 8, T. 11 S., R. 28 E., Flagler Co.	31	4632	Pre-Mesozoic ~~Rhyolite tuff & agglomerate~~	Electric log available Top of pre-Mesozoic volcanic rocks 4588 ft.
FL-56	Grace Drilling Co. No. 1 Retail Lumber Co.	Sec. 2, T. 15 S., R. 30 E., Volusia Co.	45	5424	Pre-Mesozoic ~~Rhyolite (?)~~	Electric log available Top of pre-Mesozoic ~~rocks~~ rhyolite 5403 ft.
FL-57	Sun Oil Co. No. 1 Powell Land Co.	Sec. 11, T. 17 S., R. 31 E., Volusia Co.	48	5958	Pre-Mesozoic ~~Hornblende diorite~~	Electric log available Top of pre-Mesozoic ~~rocks~~ hornblende diorite 5910 ft.

FLORIDA

No.	Well name	Location	Alt.	Total Depth	Oldest rocks reported	Notes
FL-58	Coastal Petroleum Co. No. 1 Ragland	Sec. 16, T. 15 S., R. 13 E., Levy Co.	14	5850	Paleozoic ~~black shale~~	Electric log available Top of Paleozoic black shale ~~rocks~~ 5810 ft.
FL-59	Sun Oil Co. No. 1 Goethe	Sec. 31, T. 14 S., R. 17 E., Levy Co.	34	3997	Paleozoic ~~quartzitic sandstone~~	Electric log available Top of Paleozoic quartzitic sandstone ~~rocks~~ 3960 ft.
FL-60	Humble Oil & Refining Co. No. 1 Robinson	Sec. 19, T. 16 S., R. 17 E., Levy Co.	58	4609	Lower Cretaceous	Electric log available
FL-61	J. S. Cosden No. 1 Lawson	Sec. 25, T. 13 S., R. 20 E., Marion Co.	195	4334	Paleozoic ~~quartzitic sandstone~~	No electric log run Top of Paleozoic quartzitic sandstone ~~rocks~~ 3660 ft. (?)
FL-62	Ocala Oil Corp. No. 1 York	Sec. 10, T. 16 S., R. 20 E., Marion Co.	80	6180	Paleozoic ~~quartzitic sandstone~~	No electric log run Top of Paleozoic quartzitic sandstone ~~rocks~~ 4100? ~~6180~~ ft.
FL-63	Sun Oil Co. No. 1 Parker	Sec. 24, T. 14 S., R. 22 E., Marion Co.	79	3845	Lower Ordovician (?)	Electric log available
FL-64	Sun Oil Co. No. 1 Camp	Sec. 16, T. 16 S., R. 23 E., Marion Co.	74	4637	Pre-Mesozoic ~~Tuff or agglomerate of rhyolite composition~~.	Electric log available Top of pre-Mesozoic volcanic rocks ~~rocks~~ 4615 ft.
FL-65	Dundee Petroleum Co. No. 1 Bushnell	Sec. 24, T. 20 S., R. 22 E., Sumter Co.	77	3090	Upper Cretaceous	No electric log available
FL-66	Ohio Oil Co. No. 1 Hernasco Corp.	Sec. 19, T. 23 S., R. 18 E., Hernando Co.	47	8472	Paleozoic ~~quartzitic sandstone~~	Electric log available Top of Paleozoic quartzitic sandstone ~~rocks~~ 7720 ft.

FLORIDA

No.	Well name	Location	Alt.	Total Depth	Oldest rocks reported	Notes
FL-67	Oil Development Co. of Florida No. 1 Arnold	Sec. 17, T. 24 S., R. 25 E., Lake Co.	120	6120	Pre-Mesozoic ~~Granite~~	Electric log available Top of pre-Mesozoic granite ~~rocks~~ 6103 ft.
FL-68	Warren Petroleum Corp. No. 1 Terry	Sec. 21, T. 23 S., R. 31 E., Orange Co.	100	6589	Pre-Mesozoic ~~igneous rock~~	Electric log available
FL-69	Hill No. 1 Oldsmar	Sec. 19, T. 28 S., R. 17 E., Hillsborough Co.	8	3255	Paleocene	No electric log run
FL-70	Coastal Petroleum Co. No. 1 Wright	Sec. 7, T. 30 S., R. 17 E., Pinellas Co.	13	11507	Lower Cretaceous	Electric log available
FL-71	Humble Oil & Refining Co. No. 1 Jameson	Sec. 7, T. 31 S., R. 22 E., Hillsborough Co.	112	10129	Pre-Mesozoic ~~Volcanic agglomerate & rhyolite~~	Electric log available Top of pre-Mesozoic volcanic rocks 10010 ft.
FL-72	Pioneer Oil Co. No. 1 Herscher-Yarnell	Sec. 28, T. 30 S., R. 25 E., Polk Co.	88	4540	Upper Cretaceous	No electric log available
FL-73	Humble Oil & Refining Co. No. 1 Carroll	Sec. 10, T. 27 S., R. 34 E., Osceola Co.	62	8049	Pre-Mesozoic ~~Altered & veined biotite granite~~	Electric log available Top of pre-Mesozoic biotite granite ~~rocks~~ 8035 ft.
FL-74	Humble Oil & Refining Co. No. 1 Hayman	Sec. 12, T. 31 S., R. 33 E., Osceola Co.	86	8798	Pre-Mesozoic ~~Rhyolite~~	Electric log available Top of pre-Mesozoic rhyolite ~~rocks~~ 8740 ft.
FL-75	Amerada Petroleum Corp. No. 1 Mitchell	Sec. 28, T. 31 S., R. 35 E., Indian River Co.	60	9488	Pre-Mesozoic ~~volcanic rocks~~	Electric log available

FLORIDA

No.	Well name	Location	Alt.	Total Depth	Oldest rocks reported	Notes
FL-76	Magnolia Petroleum Corp. No. 1 Schroeder-Manatee	Sec. 11, T. 35 S., R. 19 E., Manatee Co.	70	11228	Lower Cretaceous	Electric log available
FL-77	Humble Oil & Refining Co. No. 1 Keen	Sec. 23, T. 35 S., R. 23 E., Hardee Co.	83	11934	Pre-Mesozoic ~~Lava & pyroclas-tics~~	Electric log available Top of pre-Mesozoic volcanic rocks 11828 ft.
FL-78	Amerada Petroleum Corp. No. 1 Swenson	Sec. 5, T. 36 S., R. 34 E., Okeechobee Co.	54	10838	Pre-Mesozoic ~~volcanic rocks~~	Electric log available
FL-79	Amerada Petroleum Corp. No. 2 Cowles Magazine Co.	Sec. 19, T. 36 S., R. 40 E., St. Lucie Co.	32	12748	Pre-Mesozoic ~~Altered igneous rocks~~	Electric log available Top of pre-Mesozoic igneous rocks 12680 ft. Top of Fort Pierce fm. of U. Jurassic or L. Cretaceous age 10460 ft.
FL-80	Humble Oil & Refining Co. No. 1 Carlton Estate	Sec. 34, T. 38 S., R. 29 E., Highlands Co.	114	12985	Pre-Mesozoic ~~Rhyolite porphyry & amygdaloidal basalt~~	Electric log available Top pre-Mesozoic ~~rocks~~ rhyolite and basalt 12618 ft.
FL-81	Gulf Oil Corp. No. 1 Vanderbilt	Sec. 35, T. 41 S., R. 21 E., Charlotte Co.	22	12725	Lower Cretaceous	Electric log available
FL-82	Humble Oil & Refining Co. No. 1-A, Lowndes-Treadwell	Sec. 17, T. 42 S., R. 23 E., Charlotte Co.	20	13304	Lower Cretaceous	Electric log available
FL-83	Amerada Petroleum Corp. No. 1 Lykes Bros., Inc.	Sec. 1, T. 41 S., R. 30 E., Glades Co.	?	10993	Lower Cretaceous	Electric log available
FL-84	Coastal Petroleum Co. No. 1 Tiedke	Sec. 25, T. 42 S., R. 33 E., Glades Co.	14	13440	Upper Jurassic (?) or Lwr Cretaceous	Electric log available Top of Ft. Pierce fm. of U. Jurassic(?) or L. Cretaceous (?) age 12933 ft.

FLORIDA

No.	Well name	Location	Alt.	Total depth	Oldest rocks reported	Notes
FL-85	Amerada Petroleum Corp. No. 1 Southern States Lse.34	Sec. 34, T. 41 S., R. 39 E., Palm Beach Co.	36	11030	Lower Cretaceous	Electric log available
FL-86	Humble Oil & Refining Co. No. 1 Tucson Corp.	Sec. 35, T. 43 S., R. 40 E., Palm Beach Co.	34	13375	Upper Jurassic (?) or Lower Cretaceous (?)	Electric log available Top of U. Jurassic(?) or L. Cretaceous(?) rocks 13180 ft.
FL-87	Humble Oil & Refining Co. No. 1 F. S. L. 1004	Sec. 2, T. 48 S., R. 35 E., ~~Broward Co~~. PALM BEACH CO	31	12800	Lower Cretaceous	Oil staining in upper part of Lower Cretaceous
FL-88	California Co. No. 1 F. S. L. 224-B	Lat 26°41'07" N.; long 82°19'02" W., Boca Grande area, Lee Co.	39	13975	Lower Cretaceous	Electric log run
FL-89	California Co. No. 2 F. S. L. 224-B	Lat 26°43'06" N.; long 82°17'12" W., Boca Grande area, Lee Co.		12600	Lower Cretaceous	Electric log run ~~Top U. Cretaceous 5379 ft~~. ~~Top L. Cretaceous 8350 ft~~.
FL-90	Humble Oil & Refining Co. No. 1 Kirchoff	Sec. 23, T. 45 S., R. 24 E., Lee Co.	24	12877	Lower Cretaceous	Electric log available Oil show at 11819-11928 ft.
FL-91	Gulf Refining Co. No. 1 Consolidated Naval Stores	Sec. 27, T. 45 S., R. 26 E., Lee Co.	45	12865	Lower Cretaceous	Electric log available Tested 28° API gravity oil at 11748-799 ft.
FL-92	Humble Oil & Refining Co. No. 1 Consolidated Naval Stores	Sec. 16, T. 46 S., R. 27 E., Lee Co.	?	11893	Lower Cretaceous	Electric log available
FL-93	~~Commonwealth~~ Sun Oil Co. No. 2 Red Cattle Co.	Sec. ~~13~~ 32, T. 45 S., R. 29 E., Felda Field, Hendry Co.	~~49~~	~~6098~~ 11,485	~~Upper~~ Lower Cretaceous	Electric log ~~available~~ run. Oil produced from 11,471 to 11,485 ft.

FLORIDA

No.	Well name	Location	Alt.	Total depth	Oldest rocks reported	Notes
FL-94	Humble Oil & Refining Co. No. 2 Gulf Coast Realties Corp.	Sec. 30, T. 48 S., R. 30 E., Sunniland Field, Collier Co.	34	13512	Lower Cretaceous	Electric log available Oil produced from 11,613 to 11,626 ft.
FL-95	Humble Oil & Refining Co. No. 1 Collier	Sec. 27, T. 50 S., R. 26 E., ~~Sunniland Field~~, Collier Co.	25	12516	Lower Cretaceous	Electric log available
FL-96	McCord Oil Co., Inc. No. 1 Damoco	Sec. 31, T. 53 S., R. 35 E., Dade Co.	17	11885	Lower Cretaceous	Electric log available
FL-97	Commonwealth Oil Co. No. 1 Wiseheart	SE$\frac{1}{4}$ Sec. 16, T. 54 S., R. 35 E., Forty Mile Bend Field, Dade Co.	24	11557	Lower Cretaceous	Electric log available Oil produced from 11322 to 11339 ft. Abandoned 1955
FL-98	Humble Oil & Refining Co. No. 1 I. I. F.	Sec. 30, T. 55 S., R. 36 E., Dade Co.	15	11794	Lower Cretaceous	Electric log available
FL-99	Coastal Petroleum Co. No. 1 I. I. F.	Sec. 25, T. 55 S., R. 37 E., Dade Co.	25	11520	Lower Cretaceous	Electric log available
FL-100	East Coast Oil & Natural Gas Co. No. 1 Warwick	Sec. 12, T. 55 S., R. 40 E., Dade Co.	13	5535	Paleocene	No electric log
FL-101	Gulf Oil Corp. No. 1 State Model Land "C"	Lat 25°13'35"; long 80°40'55", T. 60 S., R. 35 E., Dade Co.	12	6030	Upper Cretaceous	Electric log available
FL-102	Peninsular Oil & Refining Co. No. 1 Cory	Sec. 6, T. 55 S., R. 34 E., Monroe Co.	14	10006	Lower Cretaceous	Electric log available
FL-103	Republic Oil Co. - Robinson No. 1 State	Sec. 29, T. 59 S., R. 40 E., Monroe Co.	23	12051	U. Jurassic (?) or Lower Cretaceous(?)	Electric log available Top of Ft. Pierce fm. of U. Jurassic(?) or L. Cretaceous (?) age, 11878 ft.

FLORIDA

No.	Well name	Location	Alt.	Total depth	Oldest rocks reported	Notes
FL-104	Sinclair Oil & Gas Co. No. 1 H. R. Williams	Sec. 24, T. 59 S., R. 40 E., Key Largo, Monroe Co.	20	11968	Upper Jurassic(?) or Lower Cretaceous(?)	Electric log available
FL-105	Gulf Oil Corp. No. 1 F. S. L. 826-G	Lat 25°0'53" N.; long 81°5'54" W. Oxfoot Bank, Monroe Co.	21	12631	Lower Cretaceous	Offshore Electric log available
FL-106	Coastal Petroleum Co. No. 1 F. S. L. 363	Sec. 32, T. 62 S., R. 38 E., Plantation Key, Monroe Co.	15	7559	Lower Cretaceous	Electric log available Live oil shows at 6702 ft.
FL-107	Florida East Coast Railway No. 1 Marathon	Sec. 10, T. 66 S., R. 32 E., Key Vaca, Monroe Co.		2310	Lower Eocene	No electric log run
FL-108	California Co. No. 1 F. S. L. 1011, Tract 2	Sec. 1, T. 67 S., R. 29 E., Big Pine Key, Monroe Co.	24	6033	Upper Cretaceous	Electric log not released, May, 1963
FL-109	Gulf Oil Corp. No. 1 F. S. L. 373	Sec. 2, T. 67 S., R. 29 E., Big Pine Key, Monroe Co.	23	15455	Upper Jurassic (?) or Lower Cretaceous	Electric log available Top of Ft. Pierce fm. of U. Jurassic(?) or L. Cretaceous age ~~at~~ 14340 ft.
FL-110	Gulf Refining Co. No. 1 F. S. L. 374	Sec. 15, T. 67 S., R. 27 E., Sugar Loaf Key, Monroe Co.	23	6100	Upper Cretaceous	Electric log available
FL-111	Gulf Oil Corp. No. 1 F. S. L. 826-Y	Lat 24°37' N.; long 82°02'21" W., Marquesas Keys, Monroe Co.	52	15475	Upper Jurassic(?) or Lower Cretaceous (?)	Offshore Electric log available
FL-112-A	California Co. No. 2 F. S. L. 1011, Tract 1	Lat 24°32'10" N.; long 82°06'40" W., Marquesas Keys, Monroe Co.		7723	Upper Cretaceous(?)	Offshore No data released, May, 1963
FL-112-B	California Co. No. 3 F. S. L. 1011, Tract 1	Lat 24°32'1" N.; long 82°06'31" W., Marquesas Keys, Monroe Co.		12850	Lower Cretaceous(?)	Offshore No data released, May, 1963

FLORIDA

No.	Well name	Location	Alt.	Total Depth	Oldest rocks reported	Notes
FL-113	Gulf Oil Corp. No. 1 O.C.S. Blk. 28	Lat 24°27'00"N.; long 82°21'45"W. Marquesas Keys, Monroe Co.		15294		Offshore No data released, March, 1966
FL-114	California Co. No. 1 O.C.S. Blk. 46	Lat 24°26'10"N., long 82°29'37"W. Marquesas Keys, Monroe Co.		7871	Upper Cretaceous	Offshore Twisted off 7871 - abandoned
FL-115	California Co. No. 1 O.C.S. Blk. 44	Lat 24°25'17"N., long 82°36'02"W. Marquesas Keys, Monroe Co.		4687	Eocene	Offshore Twisted off 4687 - abandoned No data released, May, 1963
FL-116	California Co. No. 3 F.S.L. 224-B	Lat.28°05'31.5"; long 82°52'49.9"W Honeymoon Island, Pinellas Co.		10524	Lower Cretaceous	Offshore
FL-117	Fernandina Beach No. 1 Water Well	Fernandina Beach, ~~Fla.~~ Nassau Co.	10	2130	Middle Eocene	See Fla. Geol. Survey Inf. Circ. 27, p. 9
FL-118	JOIDES group site No. 1	Lat 30°33.2'N., long 80°59.5'W. 27 miles offshore from Jacksonville, Fla.	-90	910	Middle Eocene	Composite of offshore core holes Gamma log run. Artesian head of 30-35 ft. reported in Eocene aquifers
FL-119	JOIDES group site No. 2	Lat 30°20.5'N., long 80°20'W. 63.5 miles offshore Jacksonville, Fla.	-136	1050	Middle Eocene	Offshore core hole Gamma and velocity log run
FL-120	JOIDES group site No. 5	Lat 30°22.7'N., long 80°07.5'W. 76.5 miles offshore Jacksonville, Fla.	-581	804	Upper Eocene	Composite of offshore core holes Gamma log run
FL-121	JOIDES group site No. 6	Lat 30°04.8N., long 79°14.5W 136 miles offshore Jacksonville, Fla.	-2710	393	Paleocene	Offshore core hole No geophysical log run
FL-122	JOIDES group site No. 4	Lat 31°02.5'N., long 77°43"W. 221 miles offshore from Brunswick, Ga.	-2945	585	Paleocene	Composite of offshore core holes No geophysical log run
FL-123	JOIDES group site No. 3	Lat 28°30'N., long 77°30.5'W. 181 miles offshore Jacksonville, Fla.	-3886	585	Middle Eocene	Composite of offshore core holes Gamma log run

GEORGIA

No.	Well name	Location	Alt.	Total depth	Oldest rocks reported	Notes
GA-1	Town of Groveton No. 1 Water Well	1 mile N. of Hy. 12, Groveton, Columbia Co.	500	300	Pre-Cretaceous	No electric log run Top of pre-Cretaceous rocks 135 ft.
GA-2	Georgia Training School No. 1 Water Well	Near Gracewood, Richmond Co.	136	1200	Pre-Cretaceous ~~talcose schist~~	No electric log run Top of pre-Cretaceous ~~305 ft~~. schist 305 ft.
GA-3	U. S. Geological Survey No. 1 Test Hole	0.25 mile E. of McBean-Waynesboro Rd., Burke Co.	129	620	Pre-Cretaceous	No electric log available Top of pre-Cretaceous rocks 602 ft.
GA-4	Three Creeks Oil Co. No. 2	2.5 miles E. of Greens Cut Burke Co.		1033	Pre-Cretaceous ~~crystalline rock~~	No electric log run Top of pre-Cretaceous ~~1002 ft~~. crystalline rocks 1002 ft.
GA-5	U. S. Geological Survey No. 2 Test Hole	Wrens, Jefferson Co.	445	549	Upper Cretaceous	No electric log available
GA-6	A. F Lucas & Georgia Petr.Co.	3.5 miles SW of Louisville, Jefferson Co.		1143	Pre-Cretaceous	No electric log run
GA-7	Middle Georgia Oil & Gas Co. No. 1 Lillian-B	12 miles NW of Sandersville, Washington Co.		395	Pre-Cretaceous	No electric log run Top of pre-Cretaceous rocks 395 ft.
GA-8	Town of Sandersville No. 51 Water Well	1.4 miles SW of junction Hys. 15 & 24 in Sandersville, Washington Co.	465	872	Pre-Cretaceous ~~&~~ quartzite ~~biotite gneiss~~	No electric log run Top of pre-Cretaceous quartzite and gneiss rocks 871 ft.
GA-9	Strietmann Biscuit Co. No. 1 Water Well	1.5 miles E. of Hy. 11 in SW Macon, Bibb Co.	364	303	Pre-Cretaceous	No electric log available Top of pre-Cretaceous rocks 301 ft

GEORGIA

No.	Well name	Location	Alt.	Total depth	Oldest rocks reported	Notes
GA-10	U. S. Government No. 2 Cochran Flying Field	Avondale, 8 miles S. of Macon, Bibb Co.	358	509	Pre-Cretaceous	No electric log available Top of pre-Cretaceous rocks 496 ft.
GA-11	Town of Swainsboro No. 3 Water Well	0.9 mile SW of courthouse, Swainsboro, Emanuel Co.	330	873	Middle Eocene	No electric log available
GA-12	Town of Sylvania No. 3 Water Well	Sylvania Screven Co.	202	490	Middle Eocene	No electric log available
GA-13	Gray Drilling Co. No. 1 W. M. McRae	0.2 mile NW of junction Hys. 1 & 85, 0.5 mile N of main gate, Ft. Benning, Muscogee Co.	250	445	Pre-Cretaceous	No electric log available Top of pre-Cretaceous rocks 439 ft.
GA-14	Town of Cusseta No. 1 Water Well	0.25 mile S. of junction Hys. 26 & 280, Chattahoochee Co.	550	1205	Pre-Cretaceous	No electric log available Top of pre-Cretaceous rocks 1185 ft.
GA-15	Lee Oil & Natural Gas Co. No. 1 Burgin	Land Lot 207, Land Dist. 31 4 miles SE of Buena Vista, Marion Co.	600	1770	Pre-Cretaceous	No electric log available Top of pre-Cretaceous rocks 1590 ft.
GA-16	Lee Oil & Natural Gas Co. No. 2 Winkler	7 miles SW of Putnam, Marion Co.		3990	Lower Cretaceous(?) ~~and older rocks(?)~~	Electric log run but not available
GA-17	Merica Oil Co. No. 1 Forhand	Land Lot 182, Land Dist. 1 3 miles NE of Ideal, Macon Co.	290	2140	Pre-Cretaceous ~~schist~~	Electric log available Top of pre-Cretaceous ~~rocks~~ schist 2139 ft.
GA-18	Tricon Minerals, Inc. No. 1 Duke	Land Lot ~~266~~ 44, Land Dist. ~~13~~ 14, 5 miles SW of Perry, Houston Co.	419	1494	Pre-Cretaceous ~~biotite gneiss~~	No electric log available *Top of pre-Cretaceous gneiss 1490 ft.*

GEORGIA

No.	Well name	Location	Alt.	Total depth	Oldest rocks reported	Notes
GA-19	Tricon Minerals, Inc. No. 1 Gilbert	Land Lot 266, Land Dist. ~~14~~ 13 7 miles SW of Elko, Houston Co.	367	1698	Pre-Cretaceous ~~biotite gneiss~~	Electric log available Top of pre-Cretaceous ~~rocks~~ gneiss 1685 ft.
GA-20	Merica Oil Co. No. 1 Hill	Land Lot 74, Land Dist. 1 1 mile NW of Byromville, Dooly Co.	371	2319	Pre-Cretaceous ~~Quartzite~~	Electric log available. Top of pre-Cretaceous ~~rocks~~ quartzite 2317 ft.
GA-21	Georgia-Florida Drilling Co. No. 1 Walton	Land Lot 163, Land Dist. 6, 9 miles SE of Vienna, Dooly Co.	442	3748	Pre-Cretaceous ~~rocks~~	No electric log available. Top of pre-Cretaceous metamorphic rocks 3512 ft.
GA-22	Ainsworth, Inc. No. 1 Tripp	Land Lot 306, Land Dist. 21, 4 miles S. of Pulaski-Beckley Co. line, near Hawkinsville, Pulaski Co.	280	2710	Pre-Cretaceous(?)	Electric log run to 2457 ft. available Top of serpentinized diabase 2488 ft.
GA-23	R. O. Leighton No. 1 Dana	Land Lot 280, Land Dist. 12 near Hawkinsville, Pulaski Co.	290	6035	Pre-Cretaceous	Electric log available
GA-24	Calaphor Manufacturing Corp. No. 1 McCain	0.5 mile S. of Minter, Laurens Co.	280	2548	Triassic (?) ~~diabase~~	Electric log available Top of Triassic (?) ~~rocks~~ diabase 2532 ft
GA-25	Glen Rose Oil Co. No. 1 Fowler	Land Lot 221, Ga. Mil. Dist. 1386, 6 miles W. of Soperton, Treutlen Co.	291	2125	Upper Cretaceous	No electric log available
GA-26	McCain & Nicholson No. 1 J. Gillis & H. Gillis	3 miles E. of Soperton, Ga. Mil. Dist. 1386 Treutlen Co.	351	3168	Pre-Cretaceous ~~Granite~~	Electric log available Top of pre-Cretaceous ~~rocks~~ granite 3158 ft.

GEORGIA

No.	Well name	Location	Alt.	Total depth	Oldest rocks reported	Notes
GA-27	Barnwell Drilling Co. J. L. Gillis	3 miles E. of Soperton Ga. Mil. Dist. 1386 Treutlen Co.		3239	Pre-Cretaceous ~~rocks~~	Electric log available Top of pre-Cretaceous rocks 3053 ft.
GA-28	Town of Statesboro No. 3 Water Well	SW part of Statesboro Bulloch Co.	219	921	Middle Eocene	No electric log available
GA-29	Flynn-Austin No. 1 Stephens	Land Lot 210, Land Dist. 17 9.5 miles SW of Americus, Sumter Co.	431	5240	Lower Cretaceous(?) ~~and older rocks(?)~~	No electric log available
GA-30	Town of Dawson No. 3 Water Well	E. side of Main St., Dawson, Terrell Co.	347	1028	Upper Cretaceous	No electric log available
GA-31	Kerr-McGee No. 1 Pate	Land Lot 144, Land Dist. 13 3 miles NW of Arabi, Crisp Co.	364	5008	Lower Cretaceous	Electric log available
GA-32	Dixie Oil Co. No. 1 Wilcox	7.5 miles SW of Alamo, Wheeler Co.	240	3384	Lower Cretaceous	No electric log run
GA-33	Parsons & Hoke No. 1 Spurlin	Land Lot 260, Land Dist. 7 1 mile S. of Scotland, Telfair Co.	242	4008	Lower Cretaceous	Electric log available
GA-34	Paul Parsons No. 1 Hinson	Land Lot 288, Land Dist 10 4 miles NE of Lumber City, ~~Telfair~~ Wheeler Co.	205	3630	Triassic(?) or Lower Cretaceous(?)	Electric log available
GA-35	Meadows Development Co. No. 2 Moses	Near Uvalda, Ga. Mil. Dist. 1810, Montgomery Co.	199	1619	Eocene	Electric log available
GA-36	J. E. Weatherford No. 1 Wilkes	1 mile N. of Higgston, Ga. Mil. Dist 1567, D.F.293 Montgomery Co.	293	3433	Triassic (?) ~~diabase~~	Electric log available Top of Triassic(?) ~~rocks~~ diabase 3415 ft.

GEORGIA

No.	Well name	Location	Alt.	Total depth	Oldest rocks reported	Notes
GA-37	Tropic Oil & Gas Co. No. 1 Gibson	6.5 miles SW of Lyons, Toombs Co.	198	3681	Triassic (?) ~~arkosic sandstone~~	Electric log available Top of Triassic(?) ~~rocks~~ arkosic sandstone 3663 ft.
GA-38	Felsenthal-Weatherford No. 1 Bradley	Land Lot 522, Land Dist. 2, 6 miles NE of Pine Grove, Appling Co.	229	4106	Triassic(?) ~~altered amygdaloidal basalt~~	Electric log available Top of Triassic ~~rocks~~ basalt 4095 ft.
GA-39	Savannah Oil Co. No. 1 Cherokee Hill	$2\frac{1}{2}$ miles SW of Port Wentworth, Chatham Co.	21	2131	Upper Cretaceous	No electric log run
GA-40	U. S. Geological Survey No. 1 Test Well	Fort Pulaski on Cockspur Island, Chatham Co.	8	1435	Paleocene	No electric log available
GA-41	U. S. Army Camp Stewart Water Well	1.6 miles NW of Hinesville Liberty Co.	91	816	Upper Eocene	No electric log available
GA-42	E. B. LaRue No. 1 Jelks & Rodgers	6 miles SE of Riceboro, Liberty Co.	26	4264	Pre-Cretaceous ~~Rhyolite porphyry~~	Electric log available Top of pre-Cretaceous ~~rocks~~ rhyolite porphyry 4250 ft.
GA-43	Sowega Minerals Expl. Co. No. 1 West	Land Lot 328, Land Dist. 4, 4.2 miles NW of Edison, Calhoun Co.	345	5275	Triassic (?) ~~diabase~~	Electric log available Top of Triassic(?) ~~rocks~~ diabase 5190 ft.
GA-44	Sealy No. 1 Reynolds Lumber Co.	Land Lot 2, Land Dist. 116, 6 miles NE of Pretoria, Dougherty Co.	209	5012	Lower Cretaceous	Electric log available
GA-45	J. R. Sealy No. 2 Reynolds Lumber Co.	Land Lot 374, Land Dist. 2, 5.4 miles SW of Pretoria, Dougherty Co.	192	5310	Lower Cretaceous	Electric log available
GA-46	Carpenter Oil Co. No. 1-A Nina McLean	Land Lot 275, Land Dist. 1 Coffee Co.	193	1903	Upper Cretaceous	No electric log available

GEORGIA

No.	Well name	Location	Alt.	Total depth	Oldest rocks reported	Notes
GA-47	Carpenter Oil Co. No. 1 Thurman	Land Lot 189, Land Dist. 1, 3.8 miles SE of Relee, Coffee Co.	317	4130	Lower Cretaceous	Electric log available
GA-48	Carpenter Oil Co. No. 1 Knight	Land Lot 144, Land Dist. 1, 5 miles NE of Broxton, Coffee Co.		4151	Pre- ~~Lower~~ Cretaceous (?)	Electric log available ~~Basement 4138 ft.~~ Top of pre-Cretaceous rocks 4138 ft.
GA-49	Rowland L. Taylor No. 1 Knight	Land Lot 327, Land Dist. 6, 6 miles NE of Douglas, Coffee. Co.	238	1210	Eocene	
GA-50	Operator unknown No. 1 Byars	7 miles NW of Jesup, Wayne Co.	175	1965	Eocene ~~sandstone~~	No electric log available
GA-51	Humble Oil Co. No. 1 Union Bag-Camp Paper	12.5 miles SE of Jesup, Land Lot 54, Ga. Mil. Dist. 333, Wayne Co.	65	4554	Pre-Cretaceous ~~Metamorphic rocks~~	Electric log available Top of pre-Cretaceous metamorphic rocks 4358 ft.
GA-52	The California Company No. 1 Brunswick Peninsular Corp.	Land Lot 7, Ga. Mil. Dist 333, 7.5 miles E. of McKinnon, Wayne Co.	73	4620	Pre-Cretaceous ~~Quartzite~~	Electric log available Top of pre-Cretaceous quartzite ~~rocks~~ 4570 ft.
GA-53	U. S. Biological Survey No. 4 Water Well	Boat landing, W. side Blackbeard Island, McIntosh Co.	9	711	Upper Eocene	No electric log available
GA-54	Pan-American Prod. Co. No. 1 Adam-McCaskill	Land Lot 329, Land Dist. 4, 2 miles SE of Offerman, Pierce Co.	75	4376	Pre-Cretaceous ~~Granite~~	Electric log available Top of pre-Cretaceous granite ~~rocks~~ 4348 ft.

GEORGIA

No.	Well name	Location	Alt.	Total depth	Oldest rocks ~~reported~~	Notes
GA-55	W. B. Hinton (Clark) No. 1 Adams-McCaskill	Land Lot 332, Land Dist. 4, 3 miles NE of Offerman, Pierce Co.	75	4355	Pre-Cretaceous ~~Granite~~	Electric log available Top of pre-Cretaceous ~~rocks~~ granite 4345 ft.
GA-56	Humble Oil Co. No. 1 W. F. Hellem	Land Lot 95, Land Dist. 2, 5.3 miles N. of Nahunta, Brantley Co.	52	4512	Lower Cretaceous	Electric log available
GA-57	Humble Oil Co. No. 1 W. C. McDonald	Ga. Mil. Dist. 1499, SW of Brunswick, Glynn Co.	25	4737	Pre-Cretaceous ~~Granite~~	Electric log available Top of pre-Cretaceous ~~rocks~~ granite 4737 ft.
GA-58	Humble Oil Co. No. ST-1 Union Bag-Camp Paper	Ga. Mil. Dist. 27, Spring Bluff area, Glynn Co.	24	4632	Lower Cretaceous	Electric log available
GA-59	E. B. LaRue No. 1 Massey	Colonels Island, 5 miles SW of Brunswick, Glynn Co.	20	4614	Lower Cretaceous	Electric log available
GA-60	State of Georgia No. 1 Jekyll Island Water Well	About middle of Jekyll Island, Glynn Co.	12	706	Upper Eocene	No electric log available
GA-61	Mont Warren No. 1 Chandler	Land Lot 406, Land Dist. 26, 3.5 miles W. of Cedar Springs, Early Co.	186	7320	Pre-Cretaceous ~~Paleozoic black shale~~	Electric log available Top of Triassic(?) rocks 5677 ft. Top of Paleozoic ~~rocks~~ [black shale] 6600 ft.
GA-62	Sun Oil Co. No. 1 Ellis	Land Lot 341, Land Dist. 26, Early Co.	163	3175	Upper Cretaceous	No electric log available
GA-63	Mont Warren No. 1 Harlow	Land Lot 82, Land Dist. 27, 5 miles E. of Donalsonville, Seminole Co.	145	3572	Lower Cretaceous	Electric log available

GEORGIA

No.	Well name	Location	Alt.	Total depth	Oldest rocks reported	Notes
GA-64	Mont Warren Co. No. 1 Grady Bell	Land Lot 61, Land Dist. 27, 12 miles SE of Donalsonville, Seminole Co.	114	3810	Lower Cretaceous	Electric log available
GA-65	J. R. Sealy No. 3 Spindle Top (Seminole Naval Stores)	Land Lot 142, Land Dist. 21, 16 miles SE of Donalsonville, Seminole Co.		7620	Lower Cretaceous	Electric log run
GA-66	Humble Oil Co. No. 1 J. R. Sealy	Land Lot 42, Land Dist. 14 18 miles W. of Bainbridge, Seminole Co.	96	4500	Lower Cretaceous(?)	Electric log available
GA-67	J. R. Sealy No. 1 Fee	6.5 miles W. of Recovery, Decatur Co.		3007	Upper Cretaceous	No electric log available Slight gas show reported
GA-68	Hunt Oil Co. No. 1 Metcalf	Land Lot 260, Land Dist. 21, 5 miles E. of Recovery, Decatur Co.	104	6152	Lower Cretaceous	Electric log available
GA-69	Hughes et al No. 1 Martin	Land Lot 189, Land Dist. 15 4.8 miles N. of Bainbridge, Decatur Co.	132	3718	Lower Cretaceous	Electric log available
GA-70	Renwar Oil Co. No. 1 G. E. Dollar	Land Lot 111, Land Dist. 15, Decatur Co.	129	4995	Lower Cretaceous	Electric log available
GA-71	Calvary Development Co. No. 1 Scott	Land Lot 25, Land Dist. 22, $2\frac{1}{2}$ miles SE of Amsterdam, Decatur Co.	277	4195	Lower Cretaceous	Electric log available
GA-72	Stanolind Oil & Gas Co. No. 1 Pullen	Land Lot 133, Land Dist. 10 1 mile S. of Cotton, Mitchell Co.	338	7490	Triassic (?) ~~diabase sills~~	Electric log available diabase Top of Triassic(?) 5677 ft. Top of Paleozoic rocks ~~6600~~ 7486 ft.

GEORGIA

No.	Well name	Location	Alt.	Total depth	Oldest rocks reported	Notes
GA-73	Adams Drilling Co. No. 1 Arrington	Land Lot 270, Land Dist. 8, 2 miles SW of Funston, Colquitt Co.	270	4910	Lower Cretaceous	Electric log available
GA-74	D. E. Hughes No. 1-B Rodgers	Land Lot 454, Land Dist. 12, 7 miles W. of Morven, Brooks Co.	136	3850	Upper Cretaceous	Electric log available
GA-75	Sun Oil Co. No. 1 Doster-Ladson	Land Lot 71, Land Dist. 7, 5 miles SW of Kirkland, Atkinson Co.	222	4296	Pre-Cretaceous ~~Volcanic tuff or agglomerate~~	Electric log available Top of pre-Cretaceous volcanic rocks ~~4220~~ 4282 ft.
GA-76	Wiley P. Ballard, Jr. No. 1-B Timber Prod. Co.	Land Lot 306, Land Dist. 7, 8.5 miles NW of Homerville, Clinch Co.	215	4232	Pre-Cretaceous ~~Ordovician(?) crystalline rocks~~	Electric log available Top of Ordovician(?) rocks 4010 ft.
GA-77	Hunt Oil Co. No. 2 Musgrove	Land Dist. 12, Land Lot 523, 5.5 miles SE of Homerville, Clinch Co.	171	3513	Upper Cretaceous	
GA-78	Sun Oil Co. No. 1 Barlow	Land Lot 373, Land Dist. 12, 9 miles SW of Homerville, Clinch Co.	177	3847	Pre-Cretaceous ~~Quartzitic sandstone~~	Electric log available Top of pre-Cretaceous quartzitic sandstone 3840 ft.
GA-79	Hunt Oil Co. No. 1 Musgrove	Land Lot 198, Land Dist. 12, 15 miles S. of Homerville, Clinch Co.	147	4088	Pre-Cretaceous ~~Paleozoic black shale~~	Electric log available Top of Paleozoic (?) black shale ~~rocks~~ 3953 ft.
GA-80	Luke Grace Drilling Co. No. 1 Griffis	Land Lot 36, Land Dist. 13, 8.4 miles NE of Fargo, Clinch Co.	176	4588	Pre-Cretaceous ~~Rhyolite~~	Electric log available Top of Paleozoic rocks 3843 ft.
GA-81	Humble Oil & Refining Co. No. 1 Bennett & Langsdale	Land Lot 146, Land Dist. 12, 4 miles NW of Haylow, Echols Co.	181	4185	Pre-Cretaceous ~~Paleozoic rocks~~	Electric log available Top of Paleozoic rocks 4108 ft.

GEORGIA

No.	Well name	Location	Alt.	Total Depth	Oldest rocks reported	Notes
GA-82	Hunt Oil Co. No. 4 Superior Pine Prod. Co.	Land Lot 219, Land Dist. 13, 5 miles NE of Statenville, Echols Co.	156	3916	Pre-Cretaceous	Electric log available Top of Paleozoic(?) red silty shale 3911 ft.
GA-83	Hunt Oil Co. No. 1 Superior Pine Prod. Co.	Land Lot 364, Land Dist. 13, 5 miles E of Statenville, Echols Co.	148	3865	Pre-Cretaceous	Electric log available Top of Paleozoic(?) black shale 3782 ft.
GA-84	Hunt Oil Co. No. 3 Superior Pine Prod. Co.	Land Lot 532, Land Dist. 13, 13 miles SE of Statenville, Echols Co.	143	4003	Pre-Cretaceous	Electric log available Top of Paleozoic(?) black shale 3657 ft.
GA-85	Hunt Oil Co. No. 2 Superior Pines	Land Lot 317, Land Dist. 13, 10 miles SW of Colon, Echols Co.	142	4062	Pre-Cretaceous	Electric log available Top of Paleozoic(?) quartzitic sandstone 3710 ft.
GA-86	No. W-7 Waycross Well	6 miles SE of Ruskin, Ware Co.	130	3045	Upper Cretaceous	No electric log
GA-87	The California Co. No. 1 Buie	4.5 miles NW of Tarboro, Camden Co.	65	4955	Pre-Cretaceous	Electric log available Top of pre-Cretaceous volcanic rocks 4674 ft.
GA-88	U. S. Coast Guard No. 1 tower site	Lat 31°56'53.5"N., long 41°00"W. 10 miles offshore from Savannah, Ga.	-54	161	Upper Eocene	Penetrated 5 ft. of Ocala Ls. Composite of two offshore core holes

MARYLAND

No	Well name	Location	Alt.	Total depth	Oldest rocks reported	Notes
MD-1	Anne Arundel Co. Sanitary Commission Water Well	1 mile N. of Glen Burnie Anne Arundel Co.	35	530	Pre-Mesozoic ~~Granite~~	Top of pre-Mesozoic granite 525 ft.
MD-2	Bethlehem Steel Co. No. 10 Water Well	Near Sparrows Point Baltimore Co.	10	711	Pre-Mesozoic	Top of pre-Mesozoic granite 658 ft.
MD-3	Chestertown Water Board No. 1 Water Well	Chestertown Kent Co	22	1135	Lower Cretaceous	
MD-4	City of Centerville Water Well	Centerville Queen Annes Co.	59	655	Upper Cretaceous	
MD-5	Maryland Oil and Development Co. ~~Camp Springs Elementary School~~ ~~No. 1 Water Well~~ Ed-9 Oil Test	Andrews Air Base ~~Camp Springs~~ Prince Georges Co.	240 ~~260~~	1511 ~~784~~	Lower ~~Upper~~ Cretaceous	
MD-6	Washington Gas Light Co. No. 3 Mudd	Near Brandywine Prince Georges Co.	124	1727	Triassic (?)	Electric log run. Top of Triassic (?) rocks 1492 ft.
MD-7	Washington Gas Light Co. No. 2 Thorne	Near Brandywine Prince Georges Co.	65	1478	Pre-Mesozoic	Electric log run Top of pre-Mesozoic gneiss 1430 ft.
MD-8	Washington Gas Light Co. No. 2 Moore	Near Brandywine Prince Georges Co	178	1523	Upper Cretaceous	Electric log run
MD-9	Coastal Petroleum Co.	Near Pomonkey Charles Co.	?	492	Upper Cretaceous	
MD-10	Pan American Refining Corp. Water Well	Wades Point Talbot Co.	13	1520	Upper Cretaceous	

MARYLAND

No.	Well name	Location	Alt.	Total depth	Oldest rocks reported	Notes
MD-11	Dorchester Water Co. No. CE-3 Cambridge	Cambridge Dorchester Co.	15	977	Upper Cretaceous	
MD-12	The Ohio Oil Co. No. 1 Hammond	6 miles E. of Salisbury Wicomico Co.	70	5568	Pre-Mesozoic	Electric log available Top of pre-Mesozoic quartzite or gneiss 5498 ft.
MD-13	Socony-Vacuum Oil Co. No. 1 Bethards	4.5 miles SW of Berlin Worcester Co.	45	7178	Triassic (?)	Electric log available Top of Triassic (?) gabbro 7130 ft.
MD-14	Standard Oil Co. of New Jersey No. 1 Maryland Esso	4.5 miles N. of Ocean City Worcester Co.	13	7710	Lower Cretaceous	Electric log available
MD-15	City of Crisfield Water Well	Crisfield Somerset Co.	?	1302	Upper Cretaceous	
MD-16	Washington Suburban Sanitary District No. Eb-2 Water Well	Near Forest Heights, Prince Georges Co.	22	630	Lower Cretaceous	

MASSACHUSETTS

No.	Well name	Location	Alt.	Total depth	Oldest rocks reported	Notes
MS-1	W. Manning No. 1 Water Well	Gays Head on Marthas Vineyard, Dukes Co.	125	175	Probably Pleistocene	Tertiary and Cretaceous rocks crop out along coast.
MS-2	Town of Tisbury No. 1 Water Well	NE part of Marthas Vineyard, Dukes County	115	262	Probably Pleistocene	
MS-3	U. S. Coast Guard No. 1 Coskata Life Saving Station	Northern tip of Nantucket Island, Nantucket Co.	10	301	Pleistocene	
MS-4	U. S. Air Force No. 1 Harwich	8500 ft. N. 86°W. of South & Main Sts., Harwich, Barnstable Co.	25	1000	Pre-Mesozoic	Top of pre-Mesozoic schist 435 ft.
MS-5	Operator unknown	Holden Pond near Provincetown, Barnstable Co.		264	Eocene	Tertiary rocks also reported in shallow wells at Duxbury on mainland.

NEW JERSEY

No.	Well name	Location	Alt.	Total depth	Oldest rocks reported	Notes
NJ-1	Harold Kuhn No. 1 Water Well	Near Fords Middlesex Co.	175	235	Triassic	Top of Triassic red shale 160 ft.
NJ-2	Clifford Stultz No. 1 Water Well	Cranbury Middlesex Co.	95	263	Pre-~~Cambrian~~ Mesozoic	Top of Wissahickon schist 200 ft.
NJ-3	Van Horn Oil Company No. 1 Oil Test	Millstone, Somerset Co.	100	2382	Triassic	Well started in Triassic red shale.
NJ-4	New Jersey Highway Authority No. 1 Test Hole	Telegraph Hill, Holmdel Township, Monmouth Co.	215	1039	Pre-~~Cambrian~~ Mesozoic	Top of Wissahickon schist 965 ft.
NJ-5	Monmouth Consolidated Water Co. West End Station Water Well	Long Branch Monmouth Co.		981	Upper Cretaceous	Electric log run
NJ-6	Monmouth Consolidated Water Co. No. 1 Whitesville Station Water Well	Asbury Park Monmouth Co.	30	1053	Upper Cretaceous	Electric log run
NJ-7	The New Jersey Oil & Gas Fields Company	Prospertown ~~Monmouth Co~~. Ocean Co.		1100	Lower Cretaceous	
NJ-8	Hamilton Square Water Co. No. 1 Water Well	About 4 miles E. of Trenton, Mercer County	100	235	Pre-~~Cambrian~~ Mesozoic	Top of Wissahickon schist 215 ft.
NJ-9	Maguire Air Base No. 2 Water Well	Ft. Dix, near Wrightstown, Burlington Co.	160	1139	Pre-~~Cambrian~~ Mesozoic	Top of Wissahickon schist 1100 ft.
NJ-10	The N. J. Oil & Gas Fields Co. and W & K Oil Co. No. 2 Mathews	Jacksons Mills Ocean Co.	110	5022	Pre-Mesozoic	Top of pre-Mesozoic schist 1336 ft.
NJ-11	American Water Works Water Well	Lakewood Ocean Co.		638	Upper Cretaceous	Electric log run

No.	Well name	Location	Alt.	Total Depth	Oldest rocks reported	Notes
NJ-12	Ocean County Water Dept. No. 6 Water Well	Mantoloking Ocean Co.		1052	Upper Cretaceous	Electric log run
NJ-13	Transcontinental Gas Pipeline Corp. No. 19 Test hole	About 2 mi. NW of Garden St. Parkway, Hy. 530, Ocean Co.	39	1805	Upper Cretaceous	Electric log run
NJ-14	Transcontinental Gas Pipeline Corp. No. 17 Test hole	About 6 mi. NW of Garden St. Parkway, Hy. 72, Ocean Co.	156	1741	Upper Cretaceous	Electric log run
NJ-14A	Transcontinental Gas Pipeline Corp. No. 13 Test hole	About 2.5 mi. E of Speedwell Burlington Co.	90	1519	Upper Cretaceous	Electric log run
NJ-15	Town of Beach Haven Water Well	Beach Haven Ocean Co.	5	575	Middle Miocene	
NJ-16	Transcontinental Gas Pipeline Corp. No. 15 Test hole	Near Harrisville Burlington Co.	19	1701	Upper Cretaceous	Electric log run
NJ-17	New Jersey Water Co. No. 15 Water Well	Near Barrington Camden Co.		634	Upper Cretaceous	Electric log run
NJ-18	Borough of Berlin Water Well	Berlin Camden Co.		955	Lower(?) Cretaceous	Electric log run
NJ-19	President Hotel No. 2 Water Well	Atlantic City Atlantic Co.	15	860	Middle Miocene	Electric log run
NJ-20	Borough of Clayton No. 2 Water Well	Clayton Gloucester Co.		1010	Upper Cretaceous	Electric log run
NJ-21	Town of Salem No. 1 Water Well	Near Standpipe in Salem, Salem Co.	12	1440	Pre-Mesozoic	Top of pre-Mesozoic granite 1376 ft.

NEW JERSEY

No.	Well name	Location	Alt.	Total depth	Oldest rocks reported	Notes
NJ-22	Town of Bridgetown No. 1 Water Well	On Cumberland Ave. in Northern Bridgetown Cumberland Co.	85	1651	Upper Cretaceous	See N.J. Geol. Survey Geol. Rept. No. 3, p. 54
NJ-23	The East Coast Oil Co.	1.5 miles E of Newport Cumberland Co.	15	1200	Upper Cretaceous	
NJ-24	Town of Sea Isle City Water Well	Sea Isle City Cape May Co.		897	Middle Miocene	Electric log run
NJ-25	Anchor Gas Co. No. 1 Dickinson	Higbee Beach Road on Cape May Cape May Co.	10	6408	Pre-Mesozoic	Electric log run Top of pre-Mesozoic gneiss 6344 ft.
NJ-26	U. S. Geological Survey No. 1 Island Beach	South end of Island Beach	10	3891	Pre-Mesozoic	Electric log run Top of pre-Mesozoic biotite gneiss 3798 ft.
NJ-27	U. S. Geological Survey No. 1 New Brooklyn Park	Lat 39°42'N., long 74°57'W. Camden Co.	110	2080	Pre-Mesozoic	Electric log run Top of Paleozoic metamorphic rocks 1943 ft.

NEW YORK

No.	Well name	Location	Alt.	Total depth	Oldest rocks reported	Notes
NY-1	City of New York No. 7 Boulevard Station	Emmett & Hylan Blvd., Richmond County, Staten Island	10	319	Pre-Cambrian	Top of pre-Cambrian soapstone 319 ft.
NY-2	Water Well No. K514	Near East New York Kings Co., Long Island	26	560	Pre-Mesozoic	Top of pre-Mesozoic gneiss or schist 466 ft.
NY-3	City of New York No. 2 Rockaway Beach	Rockway Park Pumping Station, Rockaway Beach, Borough of Queens	10	1049	Pre-Mesozoic	Top of pre-Mesozoic granite rock 991 ft.
NY-4	U. S. Naval Receiving Station No. 1 Water Well	Long Beach, Nassau Co.	10	1471	Pre-Mesozoic	Top of pre-Mesozoic rocks 1468 ft.
NY-5	Port Washington Water District No. 2 Water Well	Port Washington, Nassau Co.	24	369	Pre-Mesozoic	Top of pre-Mesozoic rocks 365 ft.
NY-6	Columbia University (Bellport Coast Guard Station) No. 1 ~~Test Hole~~ Schwenke Est.	Lat. 40° ~~N.~~ 43'N., Long. 72°56', on Fire Island opposite Bellport, Suffolk Co.		1956	Pre-Mesozoic	Electric log available Top of pre-Mesozoic rocks 1915 ft.
NY-7	Brookhaven National Laboratory	Lat. 40°51.5' N., long 72° 53.9' W., Suffolk Co. Long Island	113	1568	Pre-Mesozoic	Electric log run Top of weathered pre-Mesozoic igneous rock about 1540 ft.
NY-8	Brookhaven National Laboratory Water Well 6434	Lat. 40°52.4' N., long 72° 52.3' W., Suffolk Co. Long Island	85	1600	Pre-Mesozoic	Electric log run Top of pre-Mesozoic igneous rock about 1493 ft.
NY-9	Water Well No. 189	Near Orient Suffolk Co., Long Island	5	668	Pre-Mesozoic	Top of pre-Mesozoic gneiss or schist 668 ft.

NORTH CAROLINA

No.	Well name	Location	Alt.	Total depth	Oldest rocks reported	Notes
NC-1	City of Murfreesboro Water Well	Murfreesboro Hertford Co.	64	432	Upper Cretaceous	
NC-2	Pam-Beau Drilling Co. No. 1 Basnight	2 miles NW of Harrellsville Hertford Co.	?	1278	Pre-Cretaceous	No electric log available
NC-3	N. C. State Highway Commission Water Well	Gates Co. Prison Camp Gates Co.	29	615	Upper Cretaceous	
NC-4	DuGrandlee Expl. Co. No. 1 Foreman	10 miles NE of Elizabeth City Camden Co.	16	6421	Pre-Mesozoic ~~Cretaceous~~	Top of Triassic (?) rocks 3520 ft. Top of pre-Mesozoic rocks 4900 ft. Gas show 3170-4050 ft.
NC-5	U. S. Navy No. 1 Harvey Point Seaplane Base	Harvey Point Perquimans Co.	8	77	Upper Miocene	
NC-6	Town of Windsor Water Well	Windsor Bertie Co.	46	405	Upper Cretaceous	
NC-7	Esso Standard Oil Co. No. 2 North Carolina Esso	Pamlico Sound Dare Co.	21	6410	Lower Cretaceous	Electric log available
NC-8	Town of Tarboro Water Well	Tarboro Edgecombe Co.	50	349	Pre-Cretaceous	Top of pre-Cretaceous rocks 328 ft. ~~328 ft. top basement~~
NC-9	Town of Williamston Water Well	Williamston Martin Co.	60	500	Upper Cretaceous	
NC-10	Operator unknown No. 1 Roper	4 miles NW of Wenona Washington Co.		2223	Lower Cretaceous	

NORTH CAROLINA

No.	Well name	Location	Alt.	Total Depth	Oldest rocks reported	Notes
NC-11	Davidson Oil & Devel. Co. No. 1 Furbee	2 mi. NE of Wenona Washington Co.	36	2660	Lower Cretaceous	Electric log available
NC-12	Davidson Oil & Devel. Co. No. 1 Rhem	1 mi. N. of Ponzer Hyde Co.	9	3123	Lower Cretaceous	
NC-13A	Coastal Plains Oil Co. No. 1 J. M. Ballance	5.9 mi. E of Hy. 94 on N side Lake Mattamuskeet, Hyde Co.	10 est.	2005	Upper Cretaceous	No electric log run
NC-13B	Coastal Plains Oil Co. No. 1 F. F. Spencer, Jr.	2.4 mi. E of Hy. 94 on N side Lake Mattamuskeet, Hyde Co.	10 est.	1635	Upper Cretaceous	No electric log run
NC-13C	Coastal Plains Oil Co. No. 1 David Q. Holton	0.4 mi. N of Fairfield P. O. Hyde Co.	10 est.	2005	Upper Cretaceous	No electric log run
NC-13D	Coastal Plains Oil Co. No. 1 J. L. Simmons, Jr.	4.5 mi. W of Hy. 94 along N side Lake Mattamuskeet, Hyde Co.	10 est.	1685	Upper Cretaceous	No electric log run
NC-13E	Coastal Plains Oil Co. No. 2, J. L. Simmons, Jr.	8.3 mi. W of Hy. 94 along N side Lake Mattamuskeet, Hyde Co.	10 est.	2005	Upper Cretaceous	No electric log run
NC-13F	Coastal Plains Oil Co. No. 1 Walton Williams	2.3 mi. NW of Swindell Fork and Hy. 264 on SW side Lake Mattamuskeet, Hyde Co.	10 est.	2005	Upper Cretaceous	No electric log run
NC-13G	Coastal Plains Oil Co. No. 1 M. M. Swindell	2.4 mi. NE of Swindell Fork and Hy. 264 on SE side Lake Mattamuskeet, Hyde Co.	10 est.	2005	Upper Cretaceous	No electric log run

NORTH CAROLINA

No.	Well name	Location	Alt.	Total depth	Oldest rocks reported	Notes
NC-14	Esso Standard Oil Co. No. 1 Hatteras Light	Cape Hatteras Dare Co.	24	10054	Pre-Cretaceous	Electric log available Top of pre-Cretaceous granite 9878 ft.
NC-15	Dr. A. B. Williams Water Well	9 mi. E of Wilson Wilson Co.	123	335	Pre-Cretaceous	Top of pre-Cretaceous rocks 330 ft.
NC-16	Town of Farmville Water Well	Farmville Pitt Co.	80	472	Pre-Cretaceous	Top of pre-Cretaceous granite 470 ft.
NC-17	Don Langston Water Well	2 mi. N of Winterville Pitt Co.	63	378	Upper Cretaceous	
NC-18	American Metal Co. Test Hole	2.4 mi. NE of Washington Beaufort Co.	30	310	Upper Cretaceous	
NC-19	Town of LaGrange Water Well	LaGrange Lenoir Co.	105	404	Pre-Cretaceous	Top of pre-Cretaceous granite 392 ft.

NORTH CAROLINA

No.	Well name	Location	Alt.	Total depth	Oldest rocks reported	Notes
NC-20	Owner unknown Water Well	5 miles W. of Loftins Lenoir Co.	64	120	Upper Cretaceous	
NC-21	Carlton Ward Water Well	2 miles NW of Cove City Craven Co.	46	180	Upper Cretaceous	
NC-22	Carolina Petroleum Co. No. 1 Atlas Plywood	2 miles E. of Merritt Pamlico Co.	11	3425	Pre-Cretaceous	Electric log available Top of pre-Cretaceous granite 3414 ft.
NC-23	Carolina Petroleum Co. No. 1 N. C. Pulp Wood	1 mile SW of Pamlico Pamlico Co.	11	3667	Pre-Cretaceous	Electric log available Top of pre-Cretaceous granite 3657 ft.
NC-24	Carolina Petroleum Co. No. 1 Linley	1 mile E. of Merritt Pamlico Co.	16	2897	Lower Cretaceous	Electric log available
NC-25	Seymour Johnson Air Field Water Well	Goldsboro Wayne Co.	64	180	Pre-Cretaceous	Top of pre-Cretaceous rocks 180 ft.
NC-26	Town of Mt. Olive Water Well	Mt. Olive Wayne Co.	155	310	Upper Cretaceous	
NC-27	Town of Calypso Water Well	Calypso Duplin Co.	157	215	Upper Cretaceous	
NC-28	Warsaw Dress Co. Water Well	Warsaw Duplin Co.	158	153	Upper Cretaceous	
NC-29	J. O. Smith Water Well	6 miles SW of Kornegay Duplin Co.	85	111	Upper Cretaceous	

NORTH CAROLINA

No.	Well name	Location	Alt.	Total depth	Oldest rocks reported	Notes
NC-30	Henry Vann No. 1 Water Well	5 miles W. of Faison Sampson Co.	166	271	Pre-Cretaceous	Top of pre-Cretaceous schist 245 ft.
NC-31	Town of Roseboro Water Well	Roseboro Sampson Co.	134	470	Pre-Cretaceous	Top of pre-Cretaceous granite gneiss 353 ft.
NC-32	Town of Garland No. 2 Water Well	Garland Sampson Co.	139	348	Upper Cretaceous	
NC-33	American Mining & Devel. Co. No. 1 Corbett	2 miles SE of Kelly Bladen Co.	23	765	Pre-Cretaceous 690 ft.	Radioactivity log available Top of pre-Cretaceous rocks 690 ft.
NC-34	American Mining & Devel. Co. No. 1 Keith	7 miles N. of Acme and 8 miles SW of Currie Pender Co.	23	730	Pre-Cretaceous	Top of pre-Cretaceous rocks 695 ft.
NC-35	Mueller Farms Water Well	Rocky Point Pender Co.	35	580	Upper Cretaceous	
NC-36	Town of Richlands Water Well	Richlands Onslow Co.	50	535	Upper Cretaceous	
NC-37	Peter Henderson No. 1 Hoffman Forest	Sec. 21, Blk. 4, Hoffman Forest, Onslow Co.		1232	Pre-Cretaceous (?)	Well No. 2 drilled to 1239 ft. 2.5 miles N. Well No. 3 drilled 2 miles SE, to 1328 ft. ~~No data available~~.
NC-38	Gilbert and Seay No. 1 Hoffman Forest	10 miles N. of Jacksonville Onslow Co.		1430	Pre-Cretaceous	Well No. 2 drilled nearby to pre-Cretaceous rocks at 1335 ft.
NC-39	Burton Drilling Co. No. 1 Hofmann Forest	Sec. 8, Blk. 10, Hoffman Forest 5 miles S. of Belgrade Onslow Co.	44	1570	Pre-Cretaceous	Electric log available Top of basement 1562 ft.

NORTH CAROLINA

No.	Well name	Location	Alt.	Total depth	Oldest rocks reported	Notes
NC-40	U. S. Government No. 1 Camp Lejeune Water Well	1 mi. SE of Jacksonville Onslow Co.	30	567	Upper Cretaceous	
NC-41	Operator unknown No. 2 Cadco	4 mi. SW of Verona Onslow Co.	?	1493	Pre-Cretaceous	Top of pre-Cretaceous rocks 1343 ft.
NC-42	Operator unknown No. 1 Cadco	Hollyridge Onslow Co.	30	1497	Pre-Cretaceous	Top of pre-Cretaceous rocks 1422 ft.
NC-43	Carolina Petroleum Co. No. 1 Bryan	1 mi. E of Ellis Lake Craven Co.	15	2435	Pre-Cretaceous	Electric log available Top of pre-Cretaceous granite 2408 ft.
NC-44	Great Lakes Drilling Co. No. 1 Havelock	5 mi. W of Havelock Craven Co.	30	2351	Pre-Cretaceous	Top of pre-Cretaceous granite 2318 ft.
NC-45	Carolina Petroleum Co. No. 1 G. Carraway	Merrimon Carteret Co.	15	4069	Pre-Cretaceous	Electric log available Top of pre-Cretaceous granite 4054 ft.
NC-46A	Carolina Petroleum Co. No. 1 N. Carraway	2 mi. S of Merrimon Carteret Co.	15	4126	Pre-Cretaceous	Electric log available Top of pre-Cretaceous granite 4120 ft.
NC-46B	Carolina Petroleum Co. No. 1 G. Yeatman	2 mi. S of Merrimon Carteret Co.	20	4097	Lower Cretaceous(?)	Electric log available
NC-47	F. L. Karsten No. 1 Laughton	3 mi. NW of Morehead City Carteret Co.	17	4044	Pre-Cretaceous	Electric log available Slight oil shows (?) Top of pre-Cretaceous granite 4030 ft.

NORTH CAROLINA

No.	Well name	Location	Alt.	Total Depth	Oldest rocks reported	Notes
NC-48	Coastal Plains Oil Co. No. 1 Huntley-Davis	0.5 mi. N Harkers Island Bridge, Carteret Co.		4975	Pre-Cretaceous(?)	Electric log available Top of pre-Cretaceous rocks 4954 ft.
NC-49	Coastal Plains Oil Co. No. 1 Baylands	2.5 mi. N of Atlantic Carteret Co.		5607	Pre-Cretaceous(?)	Electric log available Top of pre-Cretaceous rocks 5561 ft.
NC-50A	Carolina Petroleum Co. No. 1 Salter	1 mi. N of Merrimon Carteret Co.	13	3963	Pre-Cretaceous	Electric log available Top of pre-Cretaceous rocks 3954 ft.
NC-50B	Carolina Petroleum Co. No. 1 Phillips-State	1.5 mi. N of Merrimon Carteret Co.	10	3964	Pre-Cretaceous	Electric log available Top of pre-Cretaceous rocks 3930 ft.
NC-50C	Carolina Petroleum Co. No. 1 Wallace	W side Jerry Creek Merrimon Township Carteret Co.	11	4020	Pre-Cretaceous(?)	Electric log available Top of pre-Cretaceous(?) 4016 ft.
NC-51	North Carolina Sanitorium No. 1 Water Well	2 mi. E of McCain Hoke Co.	510	401	Pre-Cretaceous	Top of pre-Cretaceous schist 380 ft.
NC-52	U. S. Army No. 1 Maxton Glider School Water Well	3 mi. NW of Maxton Scotland Co.	208	448	Pre-Cretaceous	Top of pre-Cretaceous schist 363 ft.
NC-53	Carolina Power & Light Co. No. 2 Water Well	Lumberton Robeson Co.	165	310	Upper Cretaceous	
NC-54	Virginia Machine & Well Co. Water Well	Tabor City Columbus Co.	105	675	Upper Cretaceous	
NC-55	Town of Whiteville Water Well	Whiteville Columbus Co.	59	260	Upper Cretaceous	

NORTH CAROLINA

No.	Well name	Location	Alt.	Total Depth	Oldest rocks reported	Notes
NC-56	Brunswick County Leland Colored High School	Leland Brunswick Co.	25	300	Upper Cretaceous	
NC-57	U. S. Army Ammunition Depot No. 6 Water Well	Sunny Point Brunswick Co.	35	198	Upper Cretaceous	
NC-58	U. S. Army Fort Caswell Water Well	Fort Caswell Brunswick Co.	11	1543	Pre-Cretaceous	Top of pre-Cretaceous metamorphic rock 1540 ft.
NC-59	Clarendon Waterworks Co. No. 1 Hilton Park	Wilmington New Hanover Co.	9	1330	Pre-Cretaceous	Top of pre-Cretaceous granite 1109 ft.
NC-60	Town of Wrightsville Beach Stratigraphic Test Hole	Wrightsville Beach New Hanover Co.	5	412	Upper Cretaceous	
NC-61	E. I. DuPont de Nemours No. 1 Water Well	1.5 mi. W of Grifton Lenoir Co.	53	823	Lower Cretaceous	Electric log available
NC-62	U. S. Geological Survey No. CR-T2-62 Test Hole	2.5 mi. W of Wilmar Craven Co.	50 est.	959	Upper Cretaceous	Electric log available
NC-63A	Coastal Plains Oil Co. No. 1 Rodman	1.5 mi. W of intersection co. rds. 1609 and 1619 Beaufort Co.	15 est.	2012	Lower Cretaceous	Electric log available
NC-63B	Coastal Plains Oil Co. No. 2 Rodman	2.5 mi. S of Terra Cia Beaufort Co.	18 est.	2113	Lower Cretaceous	Electric log available
NC-63C	Coastal Plains Oil Co. No. 1 Ratcliff	1.9 mi. E of Townsite Acre Beaufort Co.	18 est.	1963	Lower Cretaceous	Electric log available

NORTH CAROLINA

No.	Well name	Location	Alt.	Total depth	Oldest rocks reported	Notes
NC-63D	Coastal Plains Oil Co. No. 1 West Dismal	4.2 mi. N of Acre Station Beaufort Co.	30 est.	1938	Lower Cretaceous	Electric log available
NC-63E	Coastal Plains Oil Co. No. 1 H. M. Jackson	1.7 mi. N of RR in Pinetown Beaufort Co.	40 est.	1526	Lower Cretaceous	Electric log available
NC-64	Socony-Mobil Oil Co. No. 1 State	Lat 35°59.8'N., long 75°51.8'W. Albemarle Sound, Dare Co.		5255	Pre-Cretaceous	Electric log run Top of pre-Cretaceous granite gneiss 5166 ft.
NC-65	Socony-Mobil Oil Co. No. 2 State	Lat 35°27.3'N., long 75°35'W. Pamlico Sound, Dare Co.		8382	Pre-Cretaceous	Electric log run Top of pre-Cretaceous gabbro(?) 8372 ft.
NC-66	Socony-Mobil Oil Co. No. 3 State	Lat 35°15'N., long 75°52'W. Pamlico Sound, Hyde Co.		7266	Pre-Cretaceous	Electric log run. Top of pre-Cretaceous rock 7227 ft.

RHODE ISLAND

No.	Well name	Location	Alt.	Total depth	Oldest rocks reported	Notes
RI-1	Block Island Water Co. Nsh 33 Water Well	Cen. So. part Block Island, Town of New Shoreham	80	165	Pre-Mesozoic(?)	Pleistocene on pre-Mesozoic granite(?), "Rotten granite" reported by Drake, Ewing and Sutton (1959,p. 152) at -80 ft. below sea level in this or near-by well.
RI-2	U. S. Corps of Engineers No. 46 Test Well	Fort Greene, Ocean Road and Old Point Judith Road	28	109	Pre-Mesozoic	Pleistocene on pre-Mesozoic granite at 95 ft.

SOUTH CAROLINA

No.	Well name	Location	Alt.	Total Depth	Oldest rocks reported	Notes
SC-1	Town of Hartsville Water Well	Hartsville Darlington Co.	170	432	Pre-Cretaceous	Top of pre-Cretaceous schist 428 ft.
SC-2	Town of Dillon Water Well	Dillon Dillon Co.	114	595	Pre-Cretaceous	Top of pre-Cretaceous rhyolite breccia 594 ft.
SC-3	Town of Florence Water Well	Florence Florence Co.	142	715	Triassic (?)	Top of Triassic (?) olivine diabase 710 ft.
SC-4	Town of Marion Water Well	Marion Marion Co.	68	1244	Pre-Cretaceous	No electric log available Top of pre-Cretaceous schist 700 ft.
SC-5	Palmetto Drilling Co. No. 1 Allsbrooks	1 mile N. of Allsbrooks Horry Co.	107	1150	Pre-Cretaceous	No electric log available Top of pre-Cretaceous rocks 1150 ft.
SC-6	Pioneer Oil Co. No. 1 Smart	12 miles SW of Conway Horry Co.	31	1429	Pre-Cretaceous	Electric log available Top of pre-Cretaceous rocks 1400 ft.
SC-7	A. B. Cruse Drilling Co. No. 1 Fannie Collins	12 miles SW of Conway Horry Co.	15	1440	Upper Cretaceous	
SC-8	Southern States Drilling Co. No. 1 Williams	28 miles N. of Georgetown Georgetown Co.	46	1397	Upper Cretaceous	No electric log available
SC-9	Town of Georgetown Water Well	Georgetown Georgetown Co.	15	1870	Upper Cretaceous	No electric log available
SC-10	Southern States Drilling Co. Oil Test	Near Rhems Williamsburg Co.	40	825	Upper Cretaceous	No electric log available

SOUTH CAROLINA

No.	Well name	Location	Alt.	Total depth	Oldest rocks reported	Notes
SC-11	Town of Sumter Water Well	Sumter Sumter Co.	162	784	Pre-Cretaceous	No electric log available Top of pre-Cretaceous granite 782 ft.
SC-12	Survey Drilling Co. Oil Test	5 miles SW of Aiken Aiken Co.	315	492	Pre-Cretaceous	Top of pre-Cretaceous granite 450 ft.
SC-13	Town of Aiken No. 266 Water Well	1 mile S. center of Aiken Aiken Co.	480	519	Pre-Cretaceous	Top of pre-Cretaceous rocks 519 ft. Electric log run
SC-14	Oil Test	Between Perry and Wagner Aiken Co.	450	1000	Pre-Cretaceous	Top of pre-Cretaceous granite 642 ft.
SC-15	U. S. Government Savannah River Project Water Well	Savannah River area Aiken Co.		1185	Pre-Cretaceous	Top of pre-Cretaceous schist 999 ft.
SC-16	Town of Vance Water Well	26 miles SE of Orangeburg Orangeburg Co.	131	839	Upper Cretaceous	No electric log available
SC-17	U. S. Government Intransit Depot Water Well	Moncks Corners Berkeley Co.	53	177	Eocene	No electric log available
SC-18	Oil Test	Near Summerville Dorchester Co.	71	2470	Pre-Cretaceous	Top of pre-Cretaceous diabase 2450 ft.
SC-19	Town of Walterboro No. 3 Water Well	Walterboro Colleton Co.	65	1500	Upper Cretaceous	
SC-20	Charleston Consolidated Railway & Lighting Co. No. 1 Water Well	Charleston Charleston Co.	10	2015	Upper Cretaceous	
SC-21	U. S. Government No. 2 Water Well	Parris Island Marine Base Beaufort Co.	18	3454	Lower Cretaceous	Electric log available

VIRGINIA

No.	Well name	Location	Alt.	Total depth	Oldest rocks reported	Notes
VA-1	Spotsylvania Co. Water Well	1 mile SW of Fredericksburg Spotsylvania Co.		263	Pre-Mesozoic	Top of pre-Mesozoic granite 229 ft.
VA-2	U. S. Navy Proving Ground Water Well	Dahlgren King George Co.	20	780	Upper Cretaceous	
VA-3	Town of Dogue Water Well	Dogue King George Co.		385	Upper Cretaceous	
VA-4	Town of Colonial Beach Water Well	Colonial Beach Westmoreland Co.		654	Upper Cretaceous	
VA-5	Westmoreland State Park Water Well	Westmoreland State Park Westmoreland Co.		631	Upper Cretaceous	
VA-6	E. Henneson Water Well	Oak Grove Westmoreland Co.	180	530	Upper Cretaceous	
VA-7	Port Royal Tomato Cannery Water Well	Port Royal Caroline Co.		240	Lower Eocene	
VA-8	Town of Bowling Green No. 23 Water Well	Bowling Green Caroline Co.	215	1550	Pre-Mesozoic	Top of pre-Mesozoic granite 1160 ft.
VA-9	Town of Warsaw Water Well	Warsaw Richmond Co.		653	Upper Cretaceous	
VA-10	Benford Trice Water Well	St. Stephens Church King & Queen Co.		470	Upper Cretaceous	

VIRGINIA

No.	Well name	Location	Alt.	Total depth	Oldest rocks reported	Notes
VA-11	A. R. Beane Water Well	Lancaster Lancaster Co.		438	Lower Eocene	
VA-12	T. A. Treakle Water Well	Palmer Lancaster Co.		740	Upper Cretaceous	
VA-13	Peaks Industrial School Water Well	1 mile SE of Peaks Hanover Co.	190	240	Lower Eocene	
VA-14	V. E. Portwood Water Well	6 miles NE of Mechanicsville Hanover Co.		350	Lower Cretaceous	
VA-15	Roberts Drilling Co. No. 1 Hugh Townsend	18 miles NE of Richmond and 3 miles SW of Manquin King William Co.	37	3278	Pre-Mesozoic	Red clastic rocks 834-2609 ft. Igneous and metamorphic fragments abundant 2083-2609 ft. Schist, quartzite and gneiss below 2609 ft. (top of pre-Mesozoic rocks).
VA-16	W. S. Reynolds Water Well	Cohoke King William Co.		555	Upper Cretaceous	
VA-17	Chesapeake Corp. ~~West Point~~ No. 1 West Point	West Point King William Co.	30	1689 ~~1284~~	Triassic (?)	Top of Triassic(?) rocks 1284 ft.
VA-18	Elkins Oil & Gas Co. No. 1 Marchant and Minter	Mathews Mathews Co.	15	2325	Pre-Mesozoic	Top of pre-Mesozoic granite 2307 ft.
VA-19	Tidewater Oil & Gas Corp. No. 1 Johr	Approx. lat 37°30' N.; long 77°15' W., Henrico Co.	145	860(?)		

VIRGINIA

No.	Well name	Location	Alt.	Total depth	Oldest rocks reported	Notes
VA-20	V. R. Shepherd Water Well	5 miles SE Highland Springs Henrico Co.		236	Lower Eocene	
VA-21	Riverview Farm Water Well	Malvern Hill Charles City Co.	42	204	Lower Eocene	
VA-22	Charles City School Water Well	Charles City Charles City Co.		205	Upper Cretaceous	
VA-23	U. S. Navy Mine Depot Water Well	2 miles NW of Yorktown York Co.	80	620	Upper Cretaceous	
VA-24	Philadelphia & Norfolk RR Co. Water Well	Cape Charles Northampton Co.	20	1810	Lower Cretaceous	
VA-25	Disputanta School for Colored Water Well	Disputanta Prince George Co.	114	219	Lower Cretaceous	
VA-26	City of Newport News No. 1 Water Supply Well	3 miles S. of Bacons Castle Surry Co.	97	1060	Lower Cretaceous	
VA-27	Newport News Gas Co.	Newport News Warwick Co.		1065	Upper Cretaceous	
VA-28	U. S. Army Fort Monroe Water Well	Fort Monroe Elizabeth Co.	10	2255	Pre-Mesozoic	Top of pre-Mesozoic granite 2246 ft.
VA-29	Town of Wakefield Water Well	Wakefield Sussex Co.		399	Upper Cretaceous	

VIRGINIA

No.	Well name	Location	Alt.	Total depth	Oldest rocks reported	Notes
VA-30	Monogram Farm Water Well	Driver Nansemond Co.	20	540	Lower Cretaceous	
VA-31	Nestle Company Water Well	1 mile N. of Suffolk Nansemond Co.		1006	Lower Cretaceous	
VA-32	Town of Whaleyville Water Well	Whaleyville Nansemond Co.		320	Lower Eocene	
VA-33	Town of Franklin Water Well	Franklin Southampton Co.		601	Lower Cretaceous	
VA-34	Town of Norfolk Water Well	5 miles E. of Norfolk Princess Anne Co.	12	1740	Lower Cretaceous	

TABLE 3. DISTRIBUTION OF DEFINITIVE FOSSILS IN WELLS ON CROSS SECTIONS (PLS. ~~8 - 15~~ 9 - 16)

Fossils listed by plate number, well number, and depth in feet.
Well numbers refer to Table 1 and Plates 1, ~~8~~, 9, 10, 11, 12, 13, 14, and 15 (corrected: 1, 10, 11, 12, 13, 14, 15, 16)

Rocks of Late Jurassic or Early Cretaceous (Neocomian) age; Rocks of early Trinity age

Plate Number	Well Number	Choffatella decipiens	Verneuilinid fauna	Pseudocyclammina sp.	Cuneolina-like form	Coskinolina(?) sp.	Nubeculinella sp.	Anchispirocyclina henbesti	Choffatella decipiens	Orbitolina texana	Reophax n. sp.	Dufrenoya texana	Atopochara trivolvis	Arcellites disciformis
9, 15 (~~8, 14~~)	FL-57													
15 (~~14~~)	FL-58													
15 (~~14~~)	FL-64													
9 (~~8~~)	FL-73													
9 (~~8~~)	FL-86		12730		*12736			*13094	11200 11580 *12259		11100 11200			
9, 16 (~~8, 15~~)	FL-104	*11709 *11847	*11660	*11709 *11923	*11836 *11923							*11549		
16 (~~15~~)	FL-109				14584	14517				13400 13510				
16 (~~15~~)	FL-111		15375	15255										
9, 13 (~~8, 12~~)	GA-42													
14 (~~13~~)	GA-59													
14 (~~13~~)	GA-61													
14 (~~13~~)	GA-72													
14 (~~13~~)	GA-75													
9, 14 (~~8, 13~~)	GA-87													
14 (~~13~~)	AL-1													
14 (~~13~~)	AL-2													
9 (~~8~~)	SC-21													
9, 12 (~~8, 11~~)	NC-14						8980	*9120	8910				8505	
9 (~~8~~)	NJ-25												4430	4400

Rocks of late Trinity age; Rocks of Fredericksburg age; Rocks of Washita age

Plate Number	Well Number	Orbitolina cf. minuta	Orbitolina texana	Dictyoconus floridanus	Caprinid fragments	Coskinolinoides texana	Lituola subgoodlandensis	Dicyclina cf. schlumbergeri	Nummoloculina heimi
9, 15 (~~8, 14~~)	FL-57						*5372		5150
15 (~~14~~)	FL-58								
15 (~~14~~)	FL-64								
9 (~~8~~)	FL-73						6760 7390		*5984 6182
9 (~~8~~)	FL-86	10120 10360	*10674	*10674		*8963 9000	9070		7500
9, 16 (~~8, 15~~)	FL-104	9780	10028 10122	10028 10122		8360			6900
16 (~~15~~)	FL-109	11490 11680 13850		12610	12190	9840 10000		*10724	*7735 8500 9470
16 (~~15~~)	FL-111		*12624 *12824	*12624 *12824		10005 10645 11080			*7902 8445 8550
9, 13 (~~8, 12~~)	GA-42								
14 (~~13~~)	GA-59								
14 (~~13~~)	GA-61								
14 (~~13~~)	GA-72								
14 (~~13~~)	GA-75								
9, 14 (~~8, 13~~)	GA-87								
14 (~~13~~)	AL-1								
14 (~~13~~)	AL-2								
9 (~~8~~)	SC-21								
9, 12 (~~8, 11~~)	NC-14						6770		
9 (~~8~~)	NJ-25								

Rocks of Woodbine age; Rocks of Eagle Ford age

Plate Number	Well Number	Cuneolina walteri	Trocholina floridana	Ammobaculites comprimatus	Ammotium braunsteini	Acruliammina longa	Trochammina rainwateri	Ammobaculites agrestis	Placopsilina langsdalensis	Planulina eaglefordensis	Valvulineria infrequens var.	Trochammina wickendeni	Gumbelina moremani	Hastigerinella moremani	Gaudryina cf. bosquensis
9, 15 (~~8, 14~~)	FL-57	5090	5090							*4868	*4868				
15 (~~14~~)	FL-58									4130	4130				
15 (~~14~~)	FL-64									*4050	*4050				
9 (~~8~~)	FL-73														
9 (~~8~~)	FL-86														
9, 16 (~~8, 15~~)	FL-104														
16 (~~15~~)	FL-109														
16 (~~15~~)	FL-111														
9, 13 (~~8, 12~~)	GA-42			3920	3970										
14 (~~13~~)	GA-59									*4220					*4220
14 (~~13~~)	GA-61			3007	3037	3034				2605	2605		2605		
14 (~~13~~)	GA-72						3495	3510			2830				2865
14 (~~13~~)	GA-75				3810			3810		*3195	*3195			*3195	
9, 14 (~~8, 13~~)	GA-87									*4125 *4290	*4125				
14 (~~13~~)	AL-1			*1025	*1025					400					
14 (~~13~~)	AL-2									840	840			840	
9 (~~8~~)	SC-21			3149	3149					2646		2646	2646		
9, 12 (~~8, 11~~)	NC-14		5790			5310			5310						
9 (~~8~~)	NJ-25														

* Fossil found in a core.

Corrected 6/23/65

PALEOCENE ROCKS

Plate number	Well Number	Borelis gunteri	Borelis floridanus	Borelis sp.	Valvulammina nassauensis	Planispirina(?) kissengenensis	Cribrospirina(?) bushnellensis	Robulus pseudomamilligerus	Robulus midwayensis	Vaginulina longiforma	Marginulina tuberculata	Anomalina midwayensis	Cibicides vulgaris	Eponides lotus	Discorbis midwayensis	Clavulinoides midwayensis	Ammobaculites paleocenicus	Globigerina triloculinoides	Globorotalia acuta	Gyroidina aequilateralis	Vaginulina midwayana	Cibicides alleni
9 ~~8~~	FL-52		*1835																			
9,15 ~~8,14~~	FL-57		*2139 *2800																			
15 ~~24~~	FL-58	2000	2050 2160																			
15 ~~24~~	FL-59	1658	1880			2142																
15 ~~24~~	FL-64	2000	2030 2430				2280															
9 ~~28~~	FL-73	3460	3078 3360																			
9 ~~8~~	FL-86			*3960 *4170																		
9,16 ~~8,25~~	FL-104	3510	3800		3610																	
16 ~~25~~	FL-105	3970	3310 3580		4200																	
16 ~~25~~	FL-111	3705	4150 4500																			
** 13 ~~12~~	** GA-26													1275	1275							
13 ~~12~~	GA-38																					
9,13 ~~8,12~~	GA-42							1960	1960	1960												
14 ~~13~~	GA-59																					
14 ~~13~~	GA-72																				1545	1590
14 ~~13~~	GA-75								1740													
16 ~~25~~	BA-2	5940 6600		7170 7700 8046																		
9 ~~8~~	SC-21							1265	1315			1205										
11 ~~20~~	MD-11								660		590											
11 ~~20~~	MD-12										1330									1340		
9 ~~8~~	NJ-25										1770		1770			1770	1890	1890	1890			

LOWER EOCENE ROCKS

Plate number	Well Number	Pseudophragmina cedarkeysensis	Gaskinolina elongata	Miscellania nassauensis	Eponides dorfi	Spiroplectammina wilcoxensis	Valvulineria wilcoxensis	Rotalia trochidiformis	Helicostegina gyralis	Alabamina wilcoxensis	Pseudophragmina stevensoni	Globorotalia wilcoxensis
9 ~~8~~	FL-52	*1435		*1635								
9,15 ~~8,14~~	FL-57	1410	1540									
15 ~~24~~	FL-58	1300	1500 1650						1300			
15 ~~24~~	FL-59	1150	1330 1560						1120			
15 ~~24~~	FL-64											
9 ~~28~~	FL-73											
9 ~~8~~	FL-86											
9,16 ~~8,25~~	FL-104											
16 ~~25~~	FL-105											
16 ~~25~~	FL-111		2845					2943				
** 13 ~~12~~	** GA-26											
13 ~~12~~	GA-38				1570							1570
9,13 ~~8,12~~	GA-42				1500	1500	1500					
14 ~~13~~	GA-59										1500	
14 ~~13~~	GA-72				1255					1255		
14 ~~13~~	GA-75											
16 ~~25~~	BA-2											
9 ~~8~~	SC-21											
11 ~~20~~	MD-11											
11 ~~20~~	MD-12											
9 ~~8~~	NJ-25											

*Fossil found in a core.
**Fossil data from nearby Root and Rey No. 1 Fowler (Herrick, 1960, p. 408-410).

Corrected 6/23/65

Rocks of Austin age

Plate Number	Well Number	Citharina texana	Planulina austiniana	Pseudogaudryinella serruleta	Kyphopyxa christneri	Ventilabrella austiniana	Ventilabrella eggeri	Loxostomum cushmani	Valvulineria infrequens	Darbyella brownstownensis	Globorotalites umbilicatus	Gumbelina moremani	Heterostomella austiniana	Dorothia alexanderi	Planulina texana
9 15 ~~8,14~~	FL-57														
15 ~~14~~	FL-58														
15 ~~14~~	FL-64														
9 ~~8~~	FL-73														
9 ~~8~~	FL-86														
16 ~~15~~	FL-105														
16 ~~15~~	FL-111														
13 ~~12~~	** GA-26														
~~12~~	GA-37														
13 ~~12~~	GA-38				2900										
9 13 ~~8,12~~	GA-42	* 3278	* 3278												
14 ~~13~~	GA-59	* 3779													
14 ~~13~~	GA-61	2000								1940	2260				
14 ~~13~~	GA-72	2625			2370								2370		
14 ~~13~~	GA-75	3050	2853		2910	2883								3125	
9 14 ~~8,13~~	GA-87	3830 3905													
14 ~~13~~	AL-1					35		35							
14 ~~13~~	AL-2	530				370	370		460						
9 ~~8~~	SC-21	2325		2145	2325										
9 ~~8~~	NC-7														
9 12 ~~8,11~~	NC-14	4380			4380							4380			4380
12 ~~11~~	NC-43														
9 12 ~~8,11~~	NC-47														
11 ~~10~~	MD-11														
11 ~~10~~	MD-12												1480		1480
11 ~~10~~	MD-13														
9 11 ~~8,10~~	MD-14														
9 ~~8~~	NJ-25														

Rocks of Taylor age

Plate Number	Well Number	Stensioina americana	Bolivinoides decoratus	Planulina dumblei	Anomalina scholtzensis	Pseudogaudryinella capitosa	Gaudryina bentonensis	Globorotalites conicus	Kyphopyxa christneri	Anomalina cosdeni	Planulina texana
9 15 ~~8,14~~	FL-57		3600		3610						
15 ~~14~~	FL-58	3180									
15 ~~14~~	FL-64	3030			3290						
9 ~~8~~	FL-73										
9 ~~8~~	FL-86	5785	5785								
16 ~~15~~	FL-105										
16 ~~15~~	FL-111										
13 ~~12~~	** GA-26				1695				1795		
~~12~~	GA-37			2157-2162							
13 ~~12~~	GA-38			2580							
9 13 ~~8,12~~	GA-42			2740				2890	3090		
14 ~~13~~	GA-59									* 3676	
14 ~~13~~	GA-61	1358	1213	1510					1591		
14 ~~13~~	GA-72		1890	1905							
14 ~~13~~	GA-75		2410 2447	2447							
9 14 ~~8,13~~	GA-87			3430		3430					
14 ~~13~~	AL-1										
14 ~~13~~	AL-2			220		320	290				
9 ~~8~~	SC-21			1645							
9 ~~8~~	NC-7			2400					2450		
9 12 ~~8,11~~	NC-14			3150					3150		
12 ~~11~~	NC-43			1125					1156		
9 12 ~~8,11~~	NC-47			1563					1738		
11 ~~10~~	MD-11					820					
11 ~~10~~	MD-12	1390		1400		1430					
11 ~~10~~	MD-13		* 1894	1750							* 1894
9 11 ~~8,10~~	MD-14			2150							
9 ~~8~~	NJ-25	2020	2020	2020		2150			2150		

Rocks of Navarro age

Plate Number	Well Number	Rudistid fragments	Asterorbis rooki	Sulcoperculina cosdeni	Lepidorbitoides several sp.	Vaughanina cubensis	Rotalia? n. sp.	Globotruncana arca	Globotruncana canaliculata	Globotruncana cretacea	Globotruncana sp.	Anomalina pseudopapillosa	Cibicides harperi	Anomalina pinguis	Robulus navarroensis	Pseudoclavulina clavata	Loxostomum plaitum var.	Planulina correcta	Dorothia bulleta	Pseudogumbelina striata	Gumbelina glabrans	Neoflabellina reticulata
9 15 ~~8,14~~	FL-57	2910		3030 3160	3030 3160																	
15 ~~14~~	FL-58	2420		2520	2520								2760									
15 ~~14~~	FL-64		2730	2660	2660								2890									
9 ~~8~~	FL-73			3841	3841	3810																
9 ~~8~~	FL-86																					
16 ~~15~~	FL-105	4870																				
16 ~~15~~	FL-111	5110		6640	6580		5200															
13 ~~12~~	** GA-26																					
~~12~~	GA-37											1851										
13 ~~12~~	GA-38											2155	2480							2300		
9 13 ~~8,12~~	GA-42								2240						2240							
14 ~~13~~	GA-59																					
14 ~~13~~	GA-61										1213									1213		
14 ~~13~~	GA-72							1850				1845										
14 ~~13~~	GA-75											1890			1890							2310
9 14 ~~8,13~~	GA-87																					
14 ~~13~~	AL-1																					
14 ~~13~~	AL-2									110												
9 ~~8~~	SC-21												1325	1525					1935			
9 ~~8~~	NC-7																					
9 12 ~~8,11~~	NC-14																					
12 ~~11~~	NC-43							944														
9 12 ~~8,11~~	NC-47							1213														
11 ~~10~~	MD-11														760	760						
11 ~~10~~	MD-12								1360								1380				1390	
11 ~~10~~	MD-13									1709				1709			1709					
9 11 ~~8,10~~	MD-14																					
9 ~~8~~	NJ-25									1980			1980					1980				

* Fossil found in a core.
** Fossil data from nearby Root and Ray No. 1 Fowler well (Herrick, 1960, p. 408-410).

Corrected 6/23/65

MIDDLE EOCENE ROCKS

Plate Number	Well Number	Dictyoconus floridanus	Lituonella floridana	Spirolina coryensis	Flintina avonparkensis	Dictyoconus americanus	Discorinopsis gunteri	Peronella dalli	Lituola watersi	Cribrobulimina cushmani	Fabularia vaughani	Textularia coryensis	Discorbis inornatus	Epistomaria semimarginata	Helicostigina gyralis
9 ~~8~~	FL-52	680				*830					*830				
9 15 ~~8,14~~	FL-57	100				470						350	1100	1100	1250
15 ~~14~~	FL-58	390		410		500 630 920					870		890		
15 ~~14~~	FL-59	45		75		255 675					255		675		
15 ~~14~~	FL-64														
9 ~~8~~	FL-73	410	410			*1400									
9 ~~8~~	FL-86	1040	1250	1010		1300		970	1010	1110	1330				
9 16 ~~8,15~~	FL-104	1100	1140	1140	1200	1310 1860	1350								
16 ~~15~~	FL-105					2327							2327		
16 ~~15~~	FL-109	1240		1240		*2250			1240						
16 ~~15~~	FL-111	1370 1960	1390	1390		2020							1460		
13 ~~12~~	** GA-26														
13 ~~12~~	GA-37														
13 ~~12~~	GA-38														
9 13 ~~8,12~~	GA-42												1040		
14 ~~13~~	GA-59												1420		
14 ~~13~~	GA-72														
14 ~~13~~	GA-75						810						1060		
9 14 ~~8,13~~	GA-87														
16 ~~15~~	BA-2	2460 4230													
11 ~~10~~	MD-12														
9 ~~8~~	NJ-25														

Plate Number	Well Number	Asterigerina texana	Asterocyclina monticellensis	Gyroidina nassauensis	Haplophragmoides tallahattensis	Cibicides blanpiedi	Eponides mexicanus	Robulus mexicanus	Robulus alatolimbatus	Anomalina umbonata	Lockhartia cushmani	Lepidocyclina cedarkeysensis	Gunteria floridana	Fabiania cubensis	Amphistegina lopeztrigoi
9 ~~8~~	FL-52														
9 15 ~~8,14~~	FL-57														
15 ~~14~~	FL-58										870	890	1040 1220	1220	
15 ~~14~~	FL-59											675			945
15 ~~14~~	FL-64														
9 ~~8~~	FL-73														
9 ~~8~~	FL-86														
9 16 ~~8,15~~	FL-104														
16 ~~15~~	FL-105						2572								
16 ~~15~~	FL-109										*2250				
16 ~~15~~	FL-111										2200				
13 ~~12~~	** GA-26		835-846												
13 ~~12~~	GA-37														
13 ~~12~~	GA-38														
9 13 ~~8,12~~	GA-42		1040	1040	1460	1460									
14 ~~13~~	GA-59		1000												1420
14 ~~13~~	GA-72														
14 ~~13~~	GA-75		960												
9 14 ~~8,13~~	GA-87	1550													
16 ~~15~~	BA-2														
11 ~~10~~	MD-12														
9 ~~8~~	NJ-25						1610	1610	1610	1610					

Plate Number	Well Number	Dictyoconus walnutensis	Clavulina floridana	Cibicides westi	Globrotalia spinulosa	Valvulineria cubensis	Lepidocyclina antillea	Cibicides mauricensis	Cibicides americanus var.	Cibicides tallahattensis	Discorbis assulata	Gyroidina soldanii var.	Valvulineria persimilis	Spiroplectammina plummerae
9 ~~8~~	FL-52													
9 15 ~~8,14~~	FL-57													
15 ~~14~~	FL-58													
15 ~~14~~	FL-59													
15 ~~14~~	FL-64	130												
9 ~~8~~	FL-73													
9 ~~8~~	FL-86													
9 16 ~~8,15~~	FL-104													
16 ~~15~~	FL-105			2572	2572									
16 ~~15~~	FL-109		*2250											
16 ~~15~~	FL-111													
13 ~~12~~	** GA-26						815-825	915						
13 ~~12~~	GA-37								760		760	760		
13 ~~12~~	GA-38			1260						1570				
9 13 ~~8,12~~	GA-42													
14 ~~13~~	GA-59						1000							
14 ~~13~~	GA-72			860			760			1095			1045	
14 ~~13~~	GA-75						1030							
9 14 ~~8,13~~	GA-87													
16 ~~15~~	BA-2					2370 2460								
11 ~~10~~	MD-12			1280										1290
9 ~~8~~	NJ-25													

* Fossil found in a core.

** Fossil data from nearby Root and Ray No. 1 Fowler well (Herrick, 1960, p. 408-410).

Corrected 6/23/65

MIOCENE ROCKS

Plate Number	Well Number	Amphistegina lessonii	Globorotalia menardii	Fucella mansfieldi	Robulus americanus	Hanzawaia concentrica	Archaias floridanus	Miogypsina antillea	Miogypsina staufferi	Textulariella barrettii	Chione ulocyma	Chione procancellata	Nonion medio-costatum	Nonion pizarrensis	Cibicides floridanus	Spiroplectammina mississippiensis	Textularia mayori
9 15 ~~8, 14~~	FL-57											47					
9 ~~8~~	FL-73										130						
9 ~~8~~	FL-86				510					510							
9 16 ~~8, 15~~	FL-104	250	280	320	330	610	710	750	770								
16 ~~15~~	FL-105	270 620															
16 ~~15~~	FL-109					380		845	905								
16 ~~15~~	FL-111				580		920	920		900							
11 ~~10~~	MD-12				650												
9 ~~8~~	NJ-25												920	920	1080	1080	1080

Plate Number	Well Number	Uvigerina superigrina	Uvigerina calvertensis	Gypsina vesicularis	Marginulina dubia	Robulus iota	Amphistegina chipolensis	Sorites(?) sp(?)	Lepidocyclina yurnagunensis	Valvulineria floridana	Rotorbinella? rosacea	Peneroplis bradyi	Bulimina inflata	Gyroidina marylandica	Angulogerina occidentalis	Siphogenerina lamellata	Buliminella elegantissima
9 15 ~~8, 14~~	FL-57																
9 ~~8~~	FL-73																
9 ~~8~~	FL-86																
9 16 ~~8, 15~~	FL-104																
16 ~~15~~	FL-105							630									
16 ~~15~~	FL-109							*500	915	380	420	745			420		
16 ~~15~~	FL-111			370	580	700	790 900	920	1080								
11 ~~10~~	MD-12		910										1100	1100		1020	
9 ~~8~~	NJ-25	1080	920														920

* Fossil found in a core.

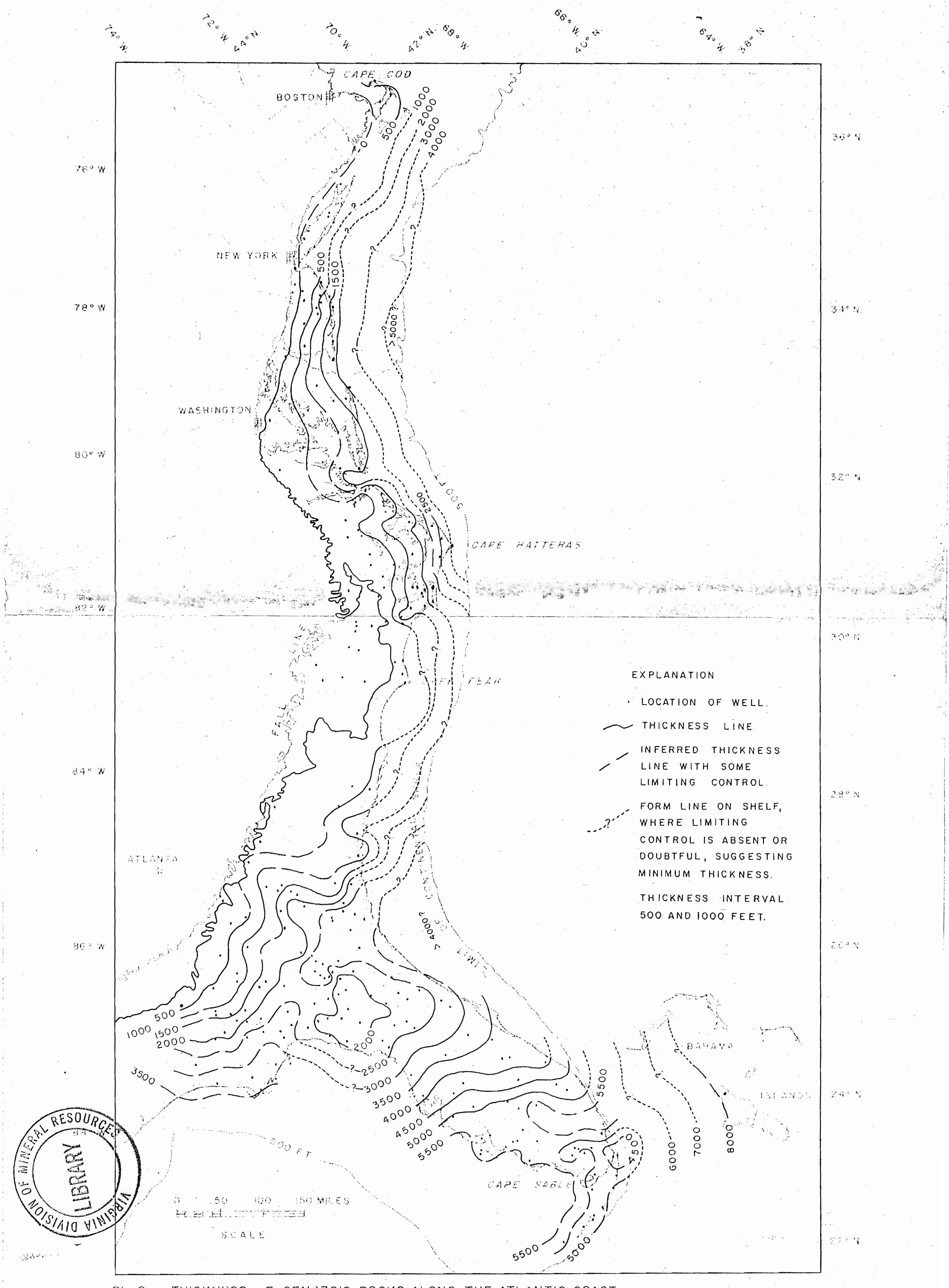
UPPER EOCENE ROCKS

Plate Number	Well Number	Lepidocyclina ocalana	Heterostegina ocalana	Amphistegina cosdeni	Operculinoides floridensis	Pseudophragmina flintensis	Asterocyclina nassauensis	Operculina mariannensis	Operculinoides moodysbranchensis	Bulimina jacksonensis	Marginulina cooperensis	Robulus virginianus	Eponides cocoaensis	Eponides jacksonensis	Uvigerina cocoaensis	Sphaerogypsina globula	Marginulina texasensis	Nonion advenum	Nonion inexcavatum	Valvulineria jacksonensis	Camerina striatoreticulatus	Operculinoides sp.	Nonionella hantkeni	Discorbis assulata
9 ~~8~~	FL-52	420		520	460	460																		
15 ~~14~~	FL-64	35			35																			
9 ~~8~~	FL-73	300	300	350																				
9 ~~8~~	FL-86																							
9 16 ~~8,15~~	FL-104																							
16 ~~15~~	FL-105	1656			1656					1772				1772	1772	1656	1772							
16 ~~15~~	FL-109																							
16 ~~15~~	FL-111																							
13 ~~12~~	** GA-8																	132	132	132				
13 ~~12~~	** GA-26													765-815					765-815					
13 ~~12~~	GA-37							740													512-520			
13 ~~12~~	GA-38				650			780													700			
13 ~~12~~	GA-41			730												511								
9 13 ~~8,12~~	GA-42		520	680	460	500	500	820	960															
14 ~~13~~	GA-59		780	900	600	700								780										
14 ~~13~~	GA-60															635						575		
14 ~~13~~	GA-72						450														450			
14 ~~13~~	GA-75		470	570	420																			
11 ~~10~~	MD-11												470										540	550
11 ~~10~~	MD-12									1160	1160		1240											
9 ~~8~~	NJ-25									1420	1420	1420-1520	1520		1520									

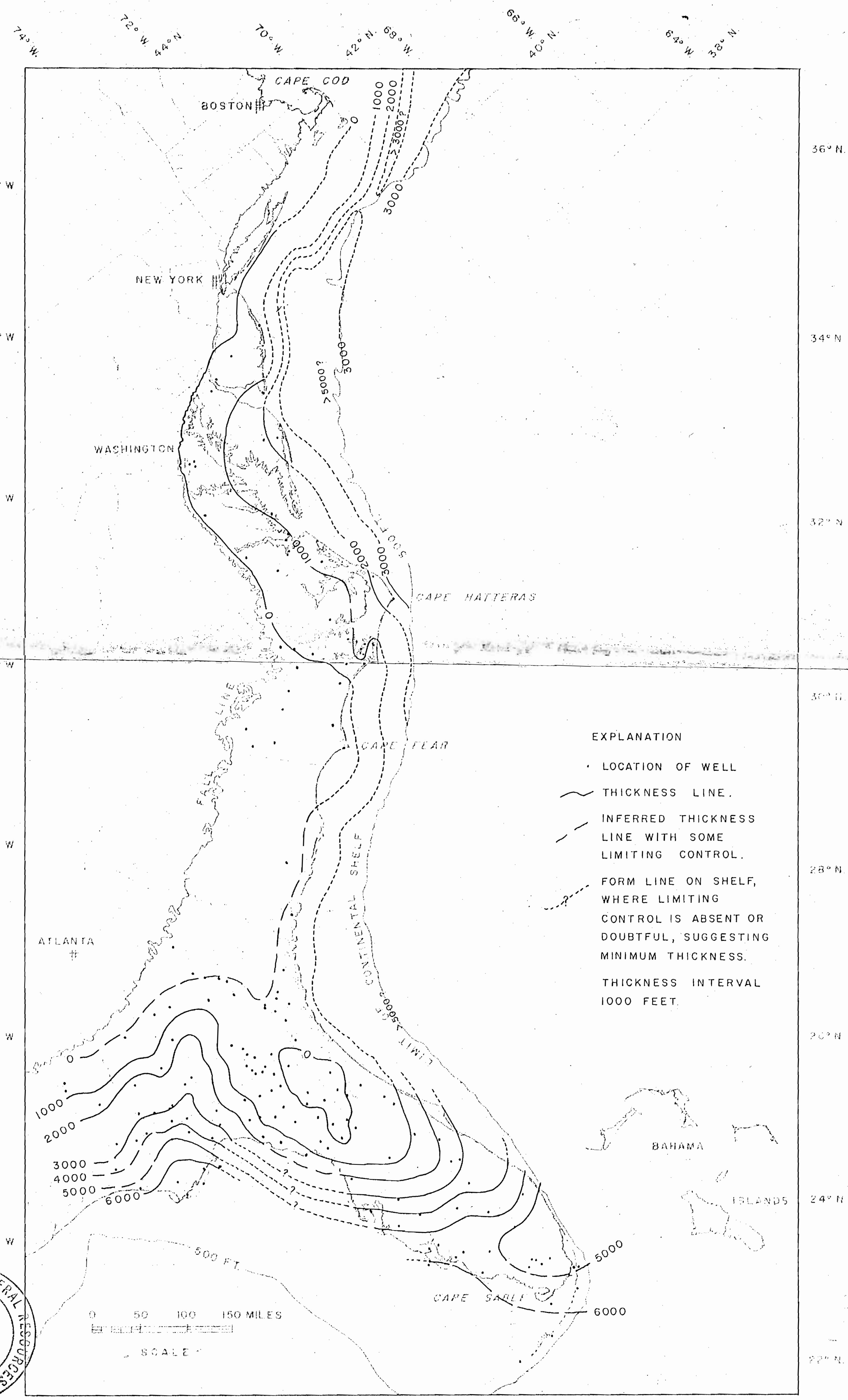
OLIGOCENE ROCKS

Plate Number	Well Number	Miogypsina gunteri	Heterostegina antillea	Camerina dia	Dictyoconus sp. (r.w.)	Miogypsina sp.	Streblus mexicanus var.	Streblus byramensis var.	Asterigerina subacuta	Dictyoconus walnutensis (r.w.)	Discorinopsis gunteri (r.w.)	Dictyoconus floridanus	Quinqueloculina leonensis	Lepidocyclina mantelli	Nonionella leonensis	Operculinoides sp.
9 ~~8~~	FL-52															
15 ~~14~~	FL-64															
9 ~~8~~	FL-73															
9 ~~8~~	FL-86				880	880										
9 16 ~~8,15~~	FL-104	980 1070	990	1020												
16 ~~15~~	FL-105															
16 ~~15~~	FL-109									1210	1210					
16 ~~15~~	FL-111		1140	1140			1260									
13 ~~12~~	** GA-8															
13 ~~12~~	** GA-26															
13 ~~12~~	GA-37						449-456									
13 ~~12~~	GA-38				580		540									
13 ~~12~~	GA-41															
9 13 ~~8,12~~	GA-42						400		400							
14 ~~13~~	GA-59						560		560						560	
14 ~~13~~	GA-60						575									575
14 ~~13~~	GA-72							370								
14 ~~13~~	GA-75							570				280	300	410		
11 ~~10~~	MD-11															
11 ~~10~~	MD-12															
9 ~~8~~	NJ-25															

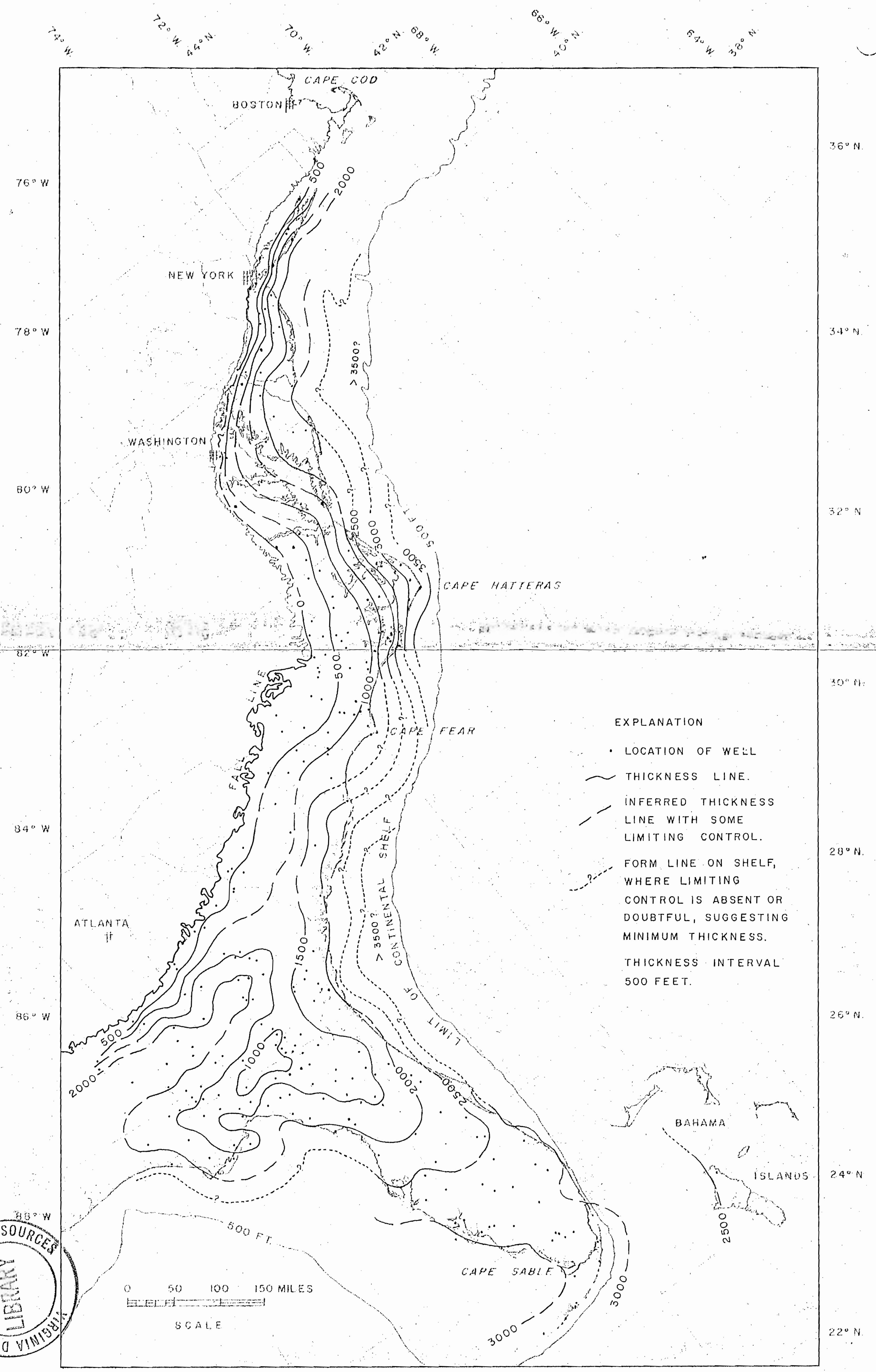
** Fossil data from nearby Layne-Atlantic No. 5 City of Sandersville and Root and Ray No. 1 Fowler wells (Herrick, 1960, p. 424-426, and 408-410).



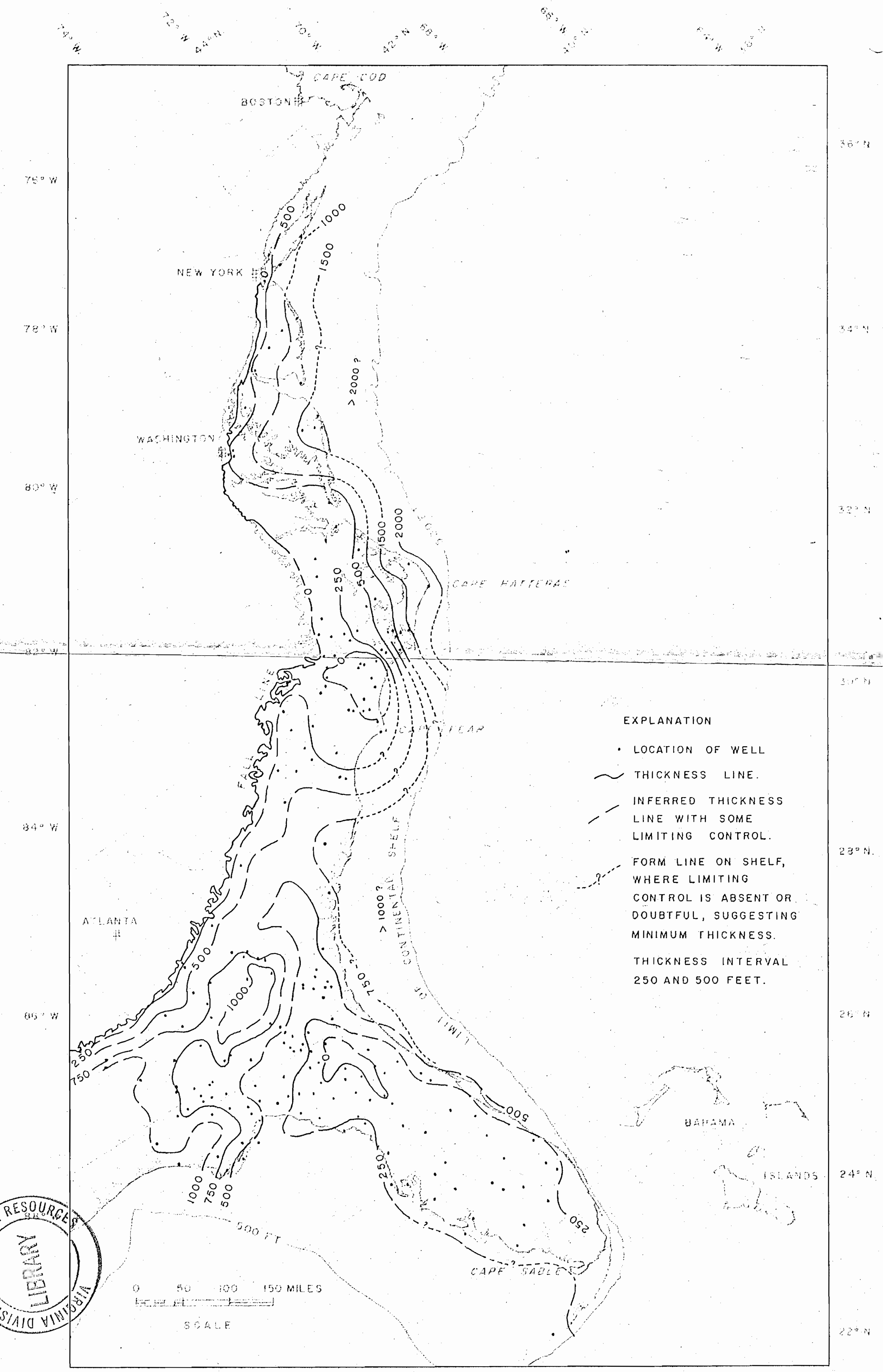
PL. 20 THICKNESS OF CENOZOIC ROCKS ALONG THE ATLANTIC COAST



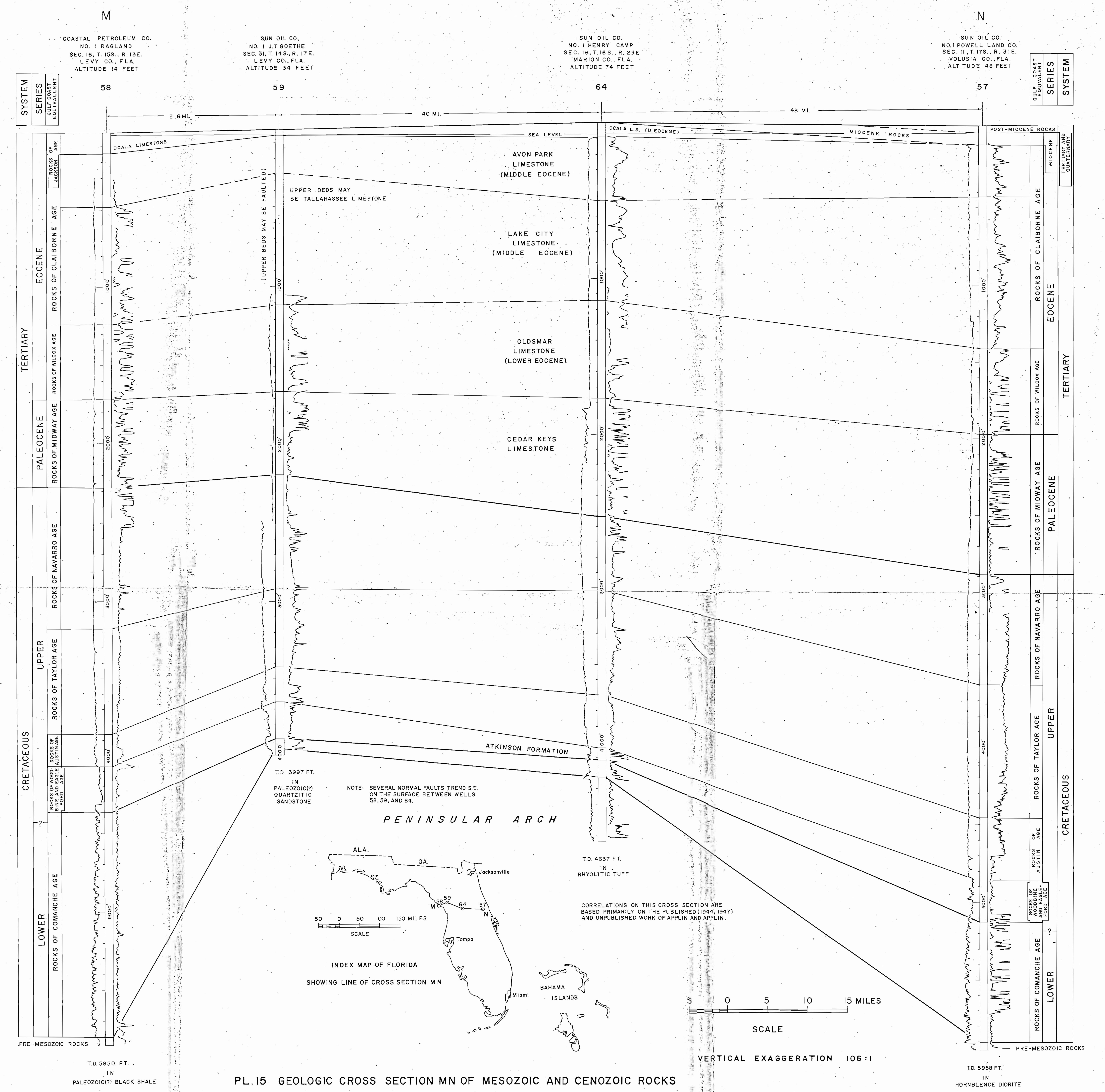
PL. 17 THICKNESS OF UPPER JURASSIC (?) AND LOWER CRETACEOUS ROCKS ALONG THE ATLANTIC COAST



PL. 18 THICKNESS OF UPPER CRETACEOUS ROCKS ALONG THE ATLANTIC COAST



PL.19 THICKNESS OF ROCKS OF WOODBINE AND EAGLE FORD AGE ALONG THE ATLANTIC COAST

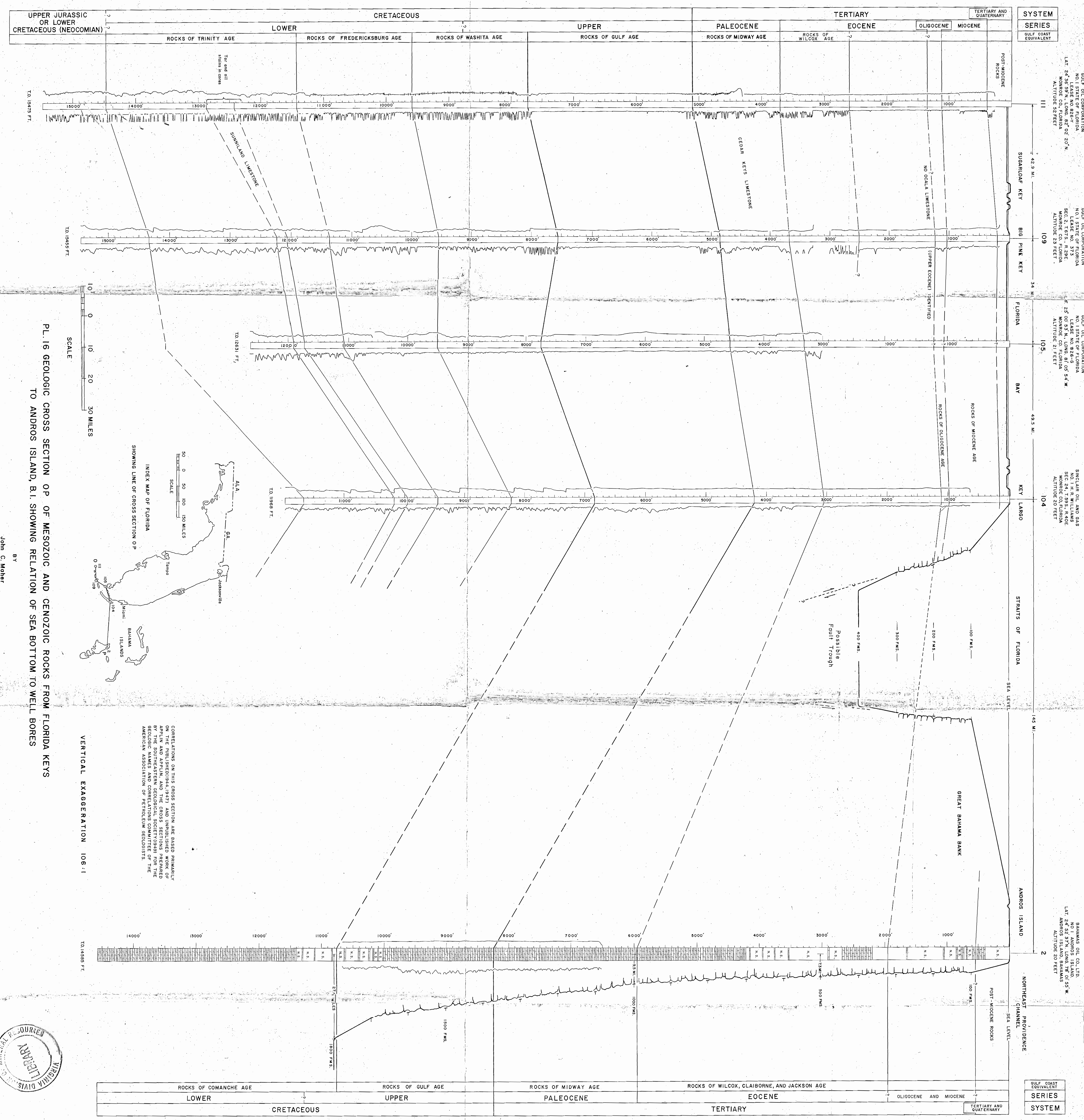


PL. 15 GEOLOGIC CROSS SECTION MN OF MESOZOIC AND CENOZOIC ROCKS ACROSS THE FLORIDA PENINSULA

BY

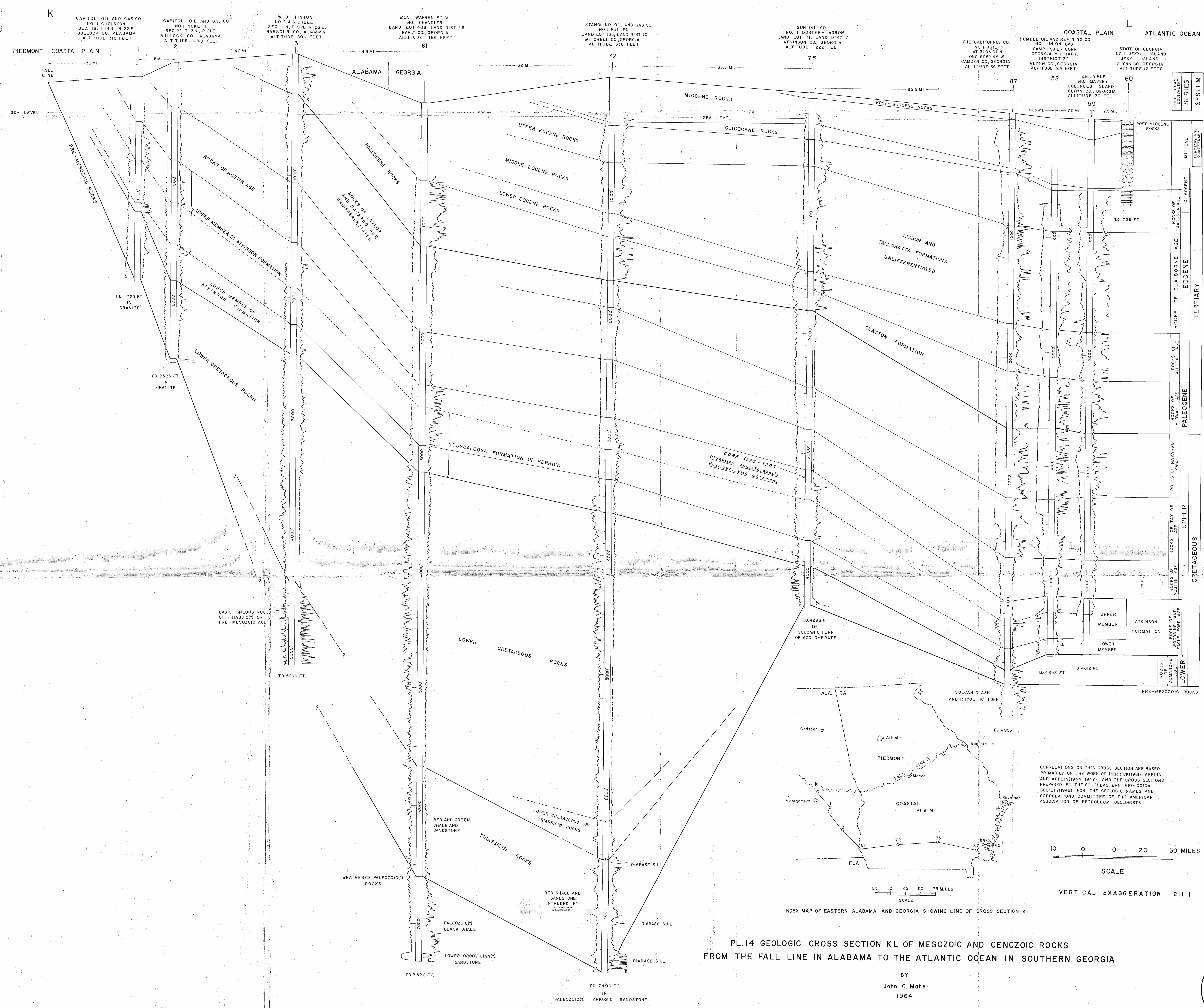
John C. Maher

1964



PL. 16 GEOLOGIC CROSS SECTION OP OF MESOZOIC AND CENOZOIC ROCKS FROM FLORIDA KEYS TO ANDROS ISLAND, B.I. SHOWING RELATION OF SEA BOTTOM TO WELL BORES

BY
John C. Maher
1964



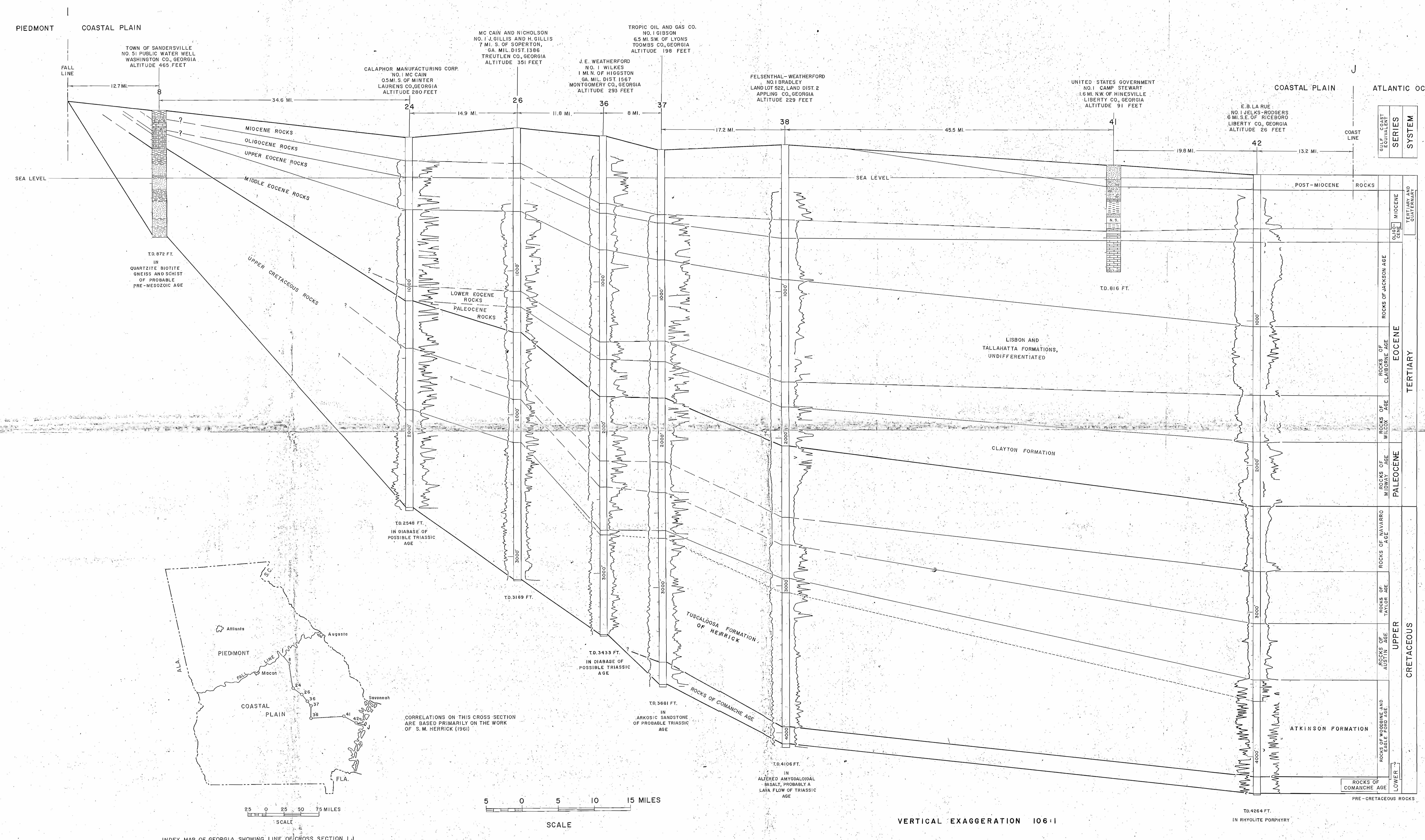
PL. 14 GEOLOGIC CROSS SECTION KL OF MESOZOIC AND CENOZOIC ROCKS FROM THE FALL LINE IN ALABAMA TO THE ATLANTIC OCEAN IN SOUTHERN GEORGIA

BY

John C. Maher

1964

Plate 14



PL. 13 GEOLOGIC CROSS SECTION I J OF MESOZOIC AND CENOZOIC ROCKS FROM THE FALL LINE TO THE ATLANTIC OCEAN IN NORTHERN GEORGIA

BY
John C. Maher
1964

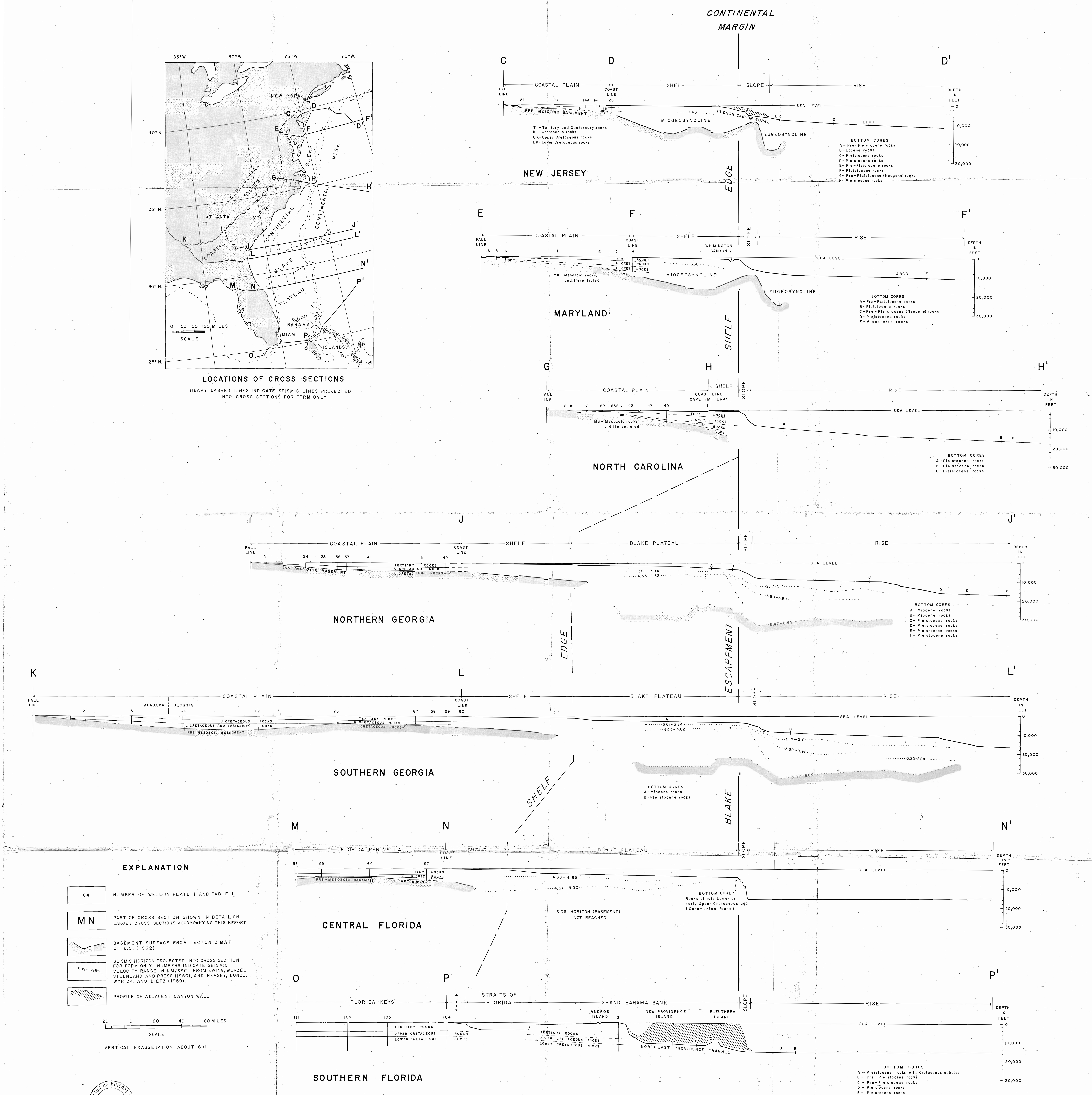
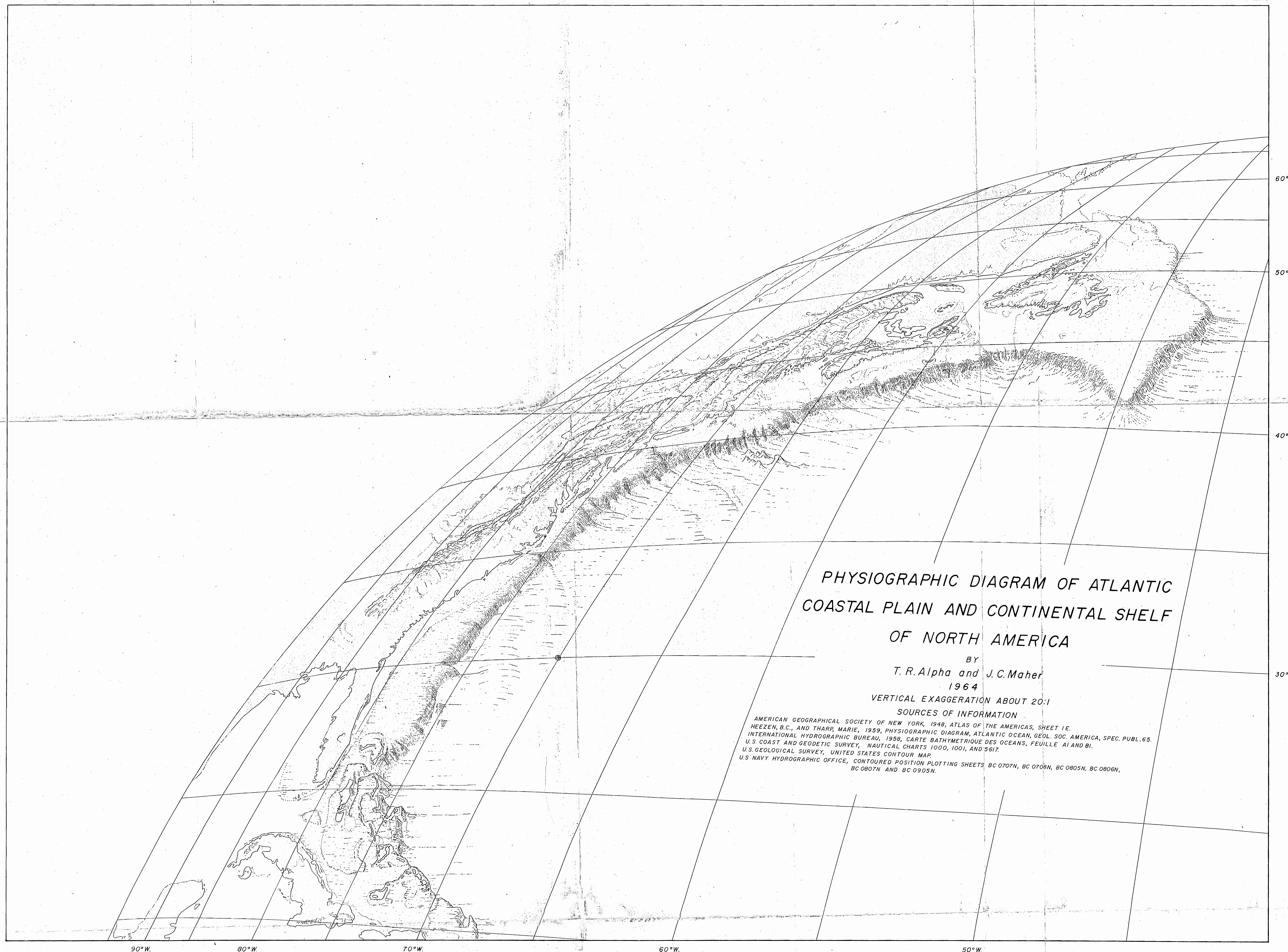


PLATE 5. DIAGRAMMATIC CROSS SECTIONS OF ATLANTIC CONTINENTAL MARGIN



PHYSIOGRAPHIC DIAGRAM OF ATLANTIC COASTAL PLAIN AND CONTINENTAL SHELF OF NORTH AMERICA

BY

T. R. Alpha and J. C. Maher

1964

VERTICAL EXAGGERATION ABOUT 20:1

SOURCES OF INFORMATION

AMERICAN GEOGRAPHICAL SOCIETY OF NEW YORK, 1948, ATLAS OF THE AMERICAS, SHEET I E.
HEEZEN, B.C., AND THARP, MARIE, 1959, PHYSIOGRAPHIC DIAGRAM, ATLANTIC OCEAN, GEOL. SOC. AMERICA, SPEC. PUBL. 65.
INTERNATIONAL HYDROGRAPHIC BUREAU, 1958, CARTE BATHYMETRIQUE DES OCEANS, FEUILLE AI AND BI.
U.S. COAST AND GEODETIC SURVEY, NAUTICAL CHARTS 1000, 1001, AND 5617.
U.S. GEOLOGICAL SURVEY, UNITED STATES CONTOUR MAP.
U.S NAVY HYDROGRAPHIC OFFICE, CONTOURED POSITION PLOTTING SHEETS BC 0707N, BC 0708N, BC 0805N, BC 0806N, BC 0807N AND BC 0905N.

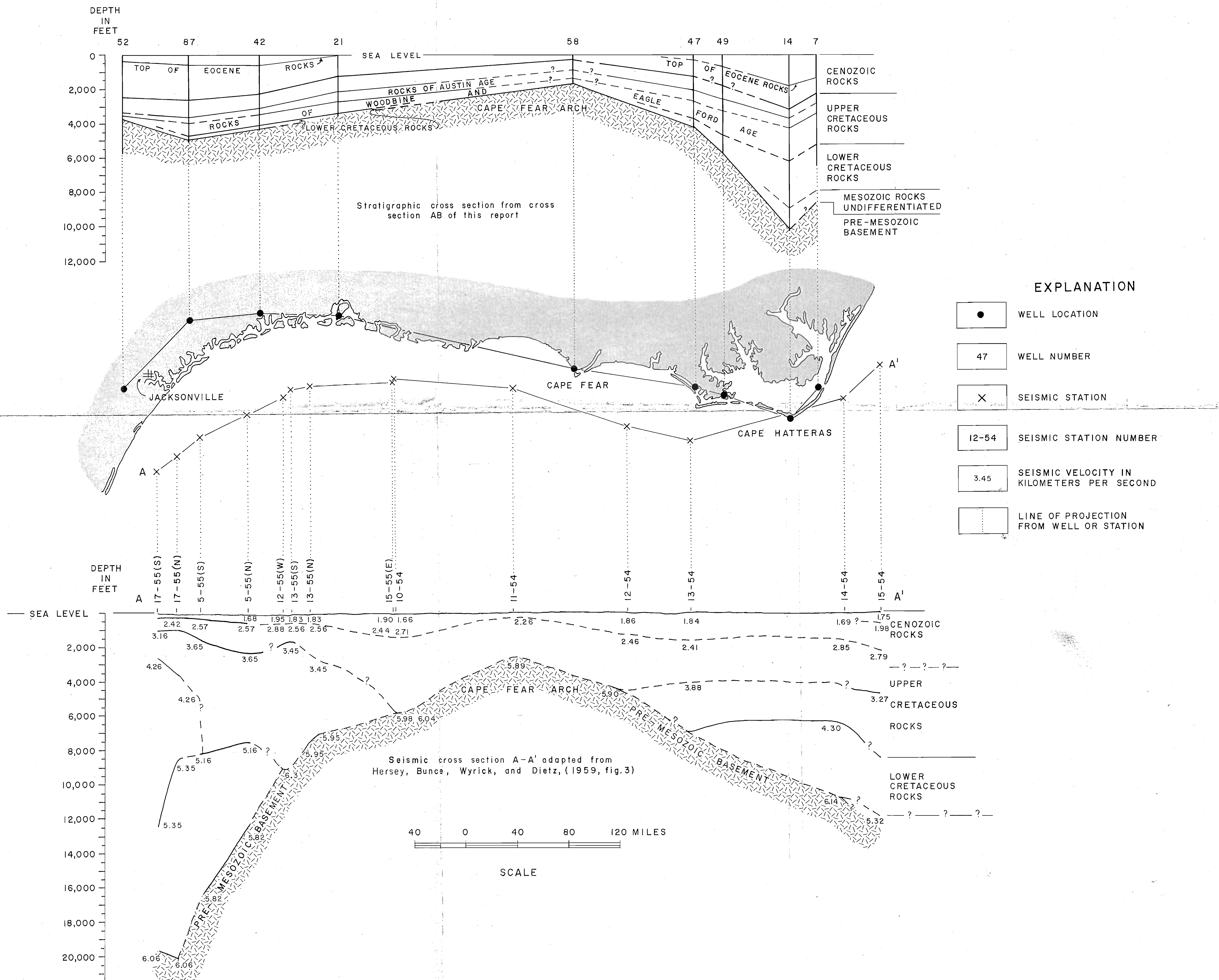
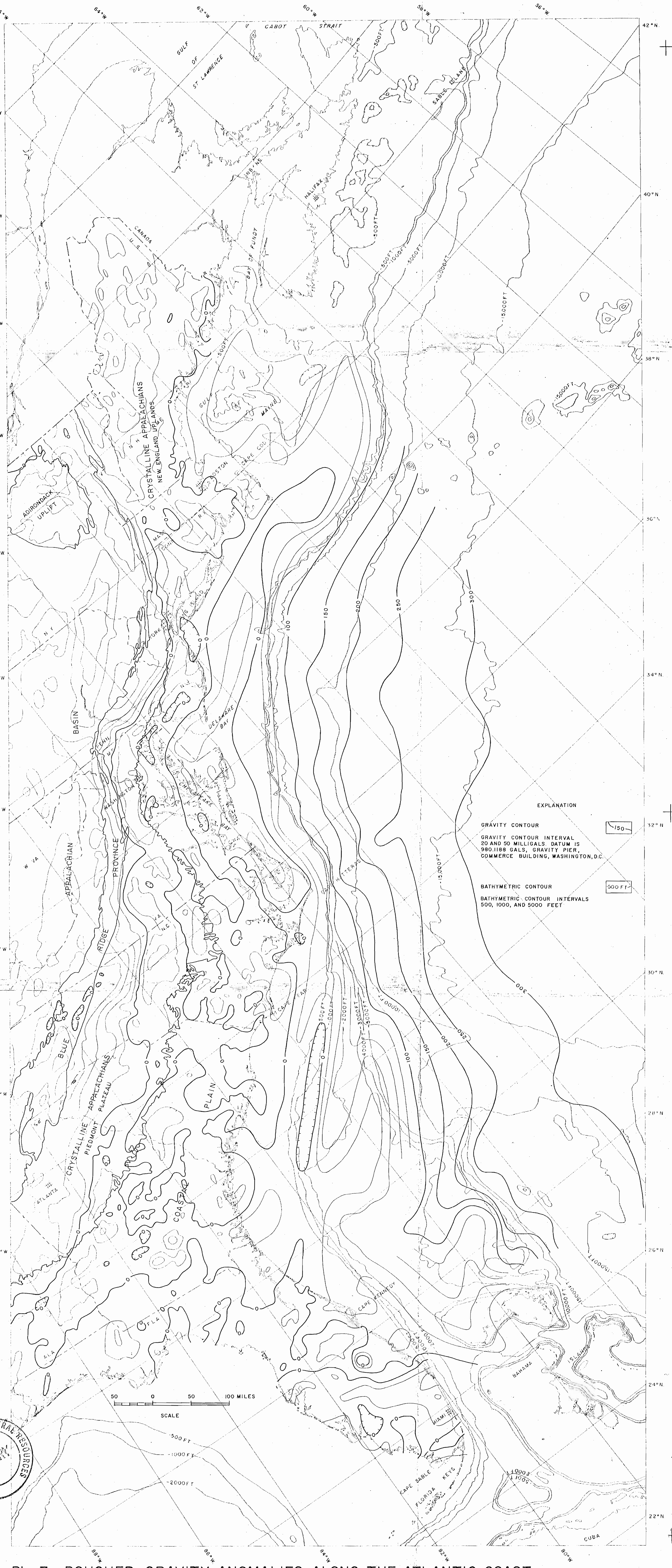
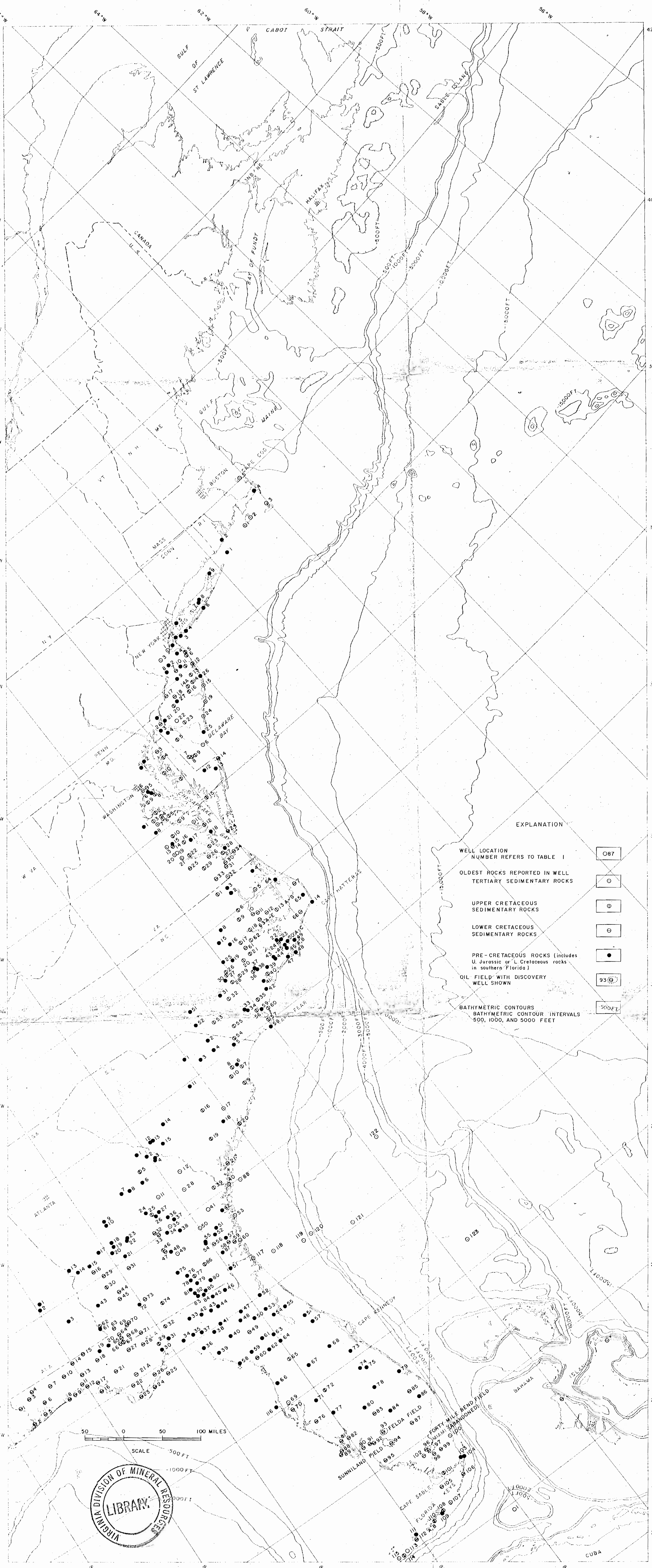


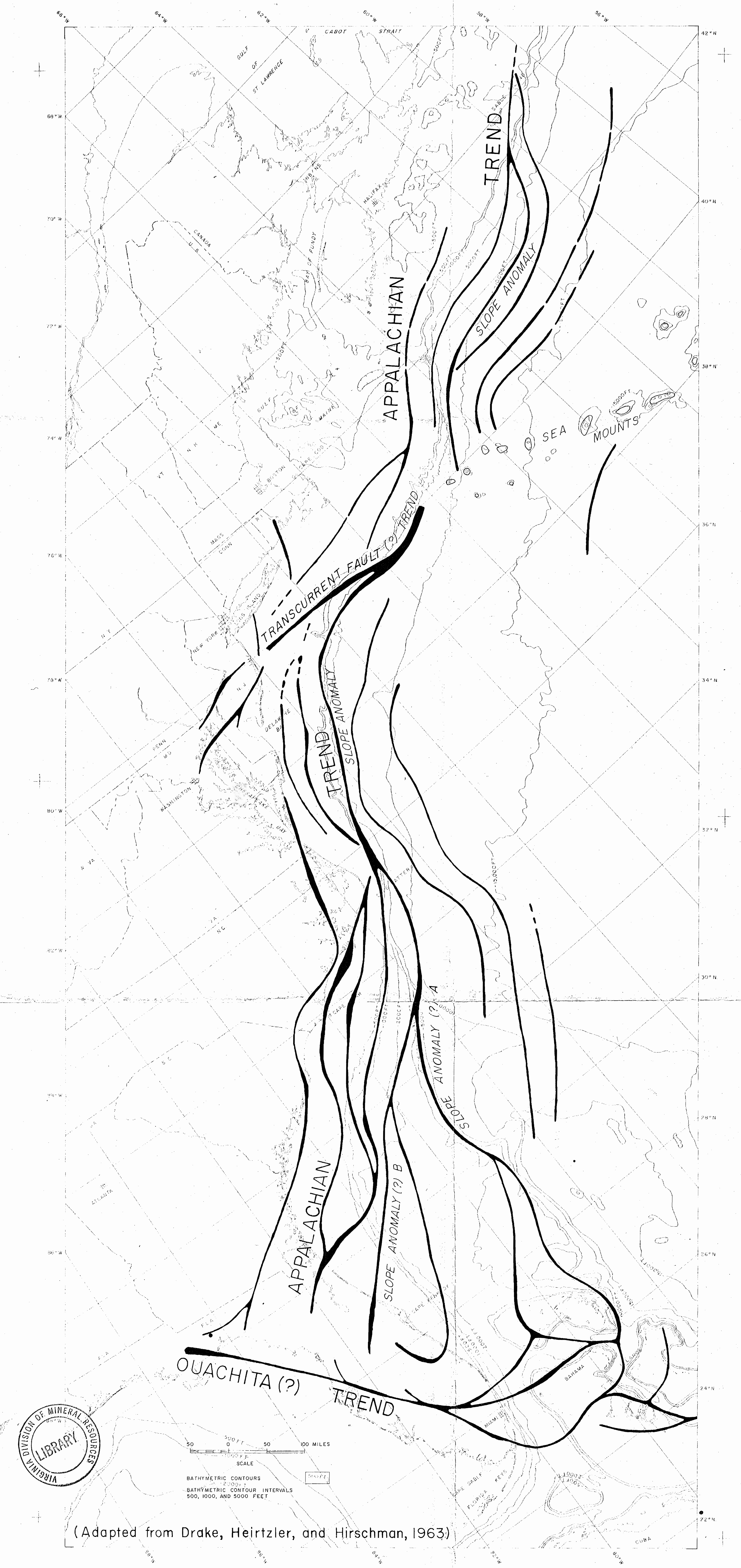
PLATE 6. DIAGRAMMATIC CROSS SECTIONS FROM JACKSONVILLE, FLORIDA TO CAPE HATTERAS, NORTH CAROLINA SHOWING RELATIONSHIP OF SEISMIC HORIZONS OFFSHORE TO SUBSURFACE GEOLOGY ONSHORE



PL. 7 BOUGUER GRAVITY ANOMALIES ALONG THE ATLANTIC COAST



PL. 1 LOCATIONS OF SELECTED WELLS ALONG THE ATLANTIC COAST



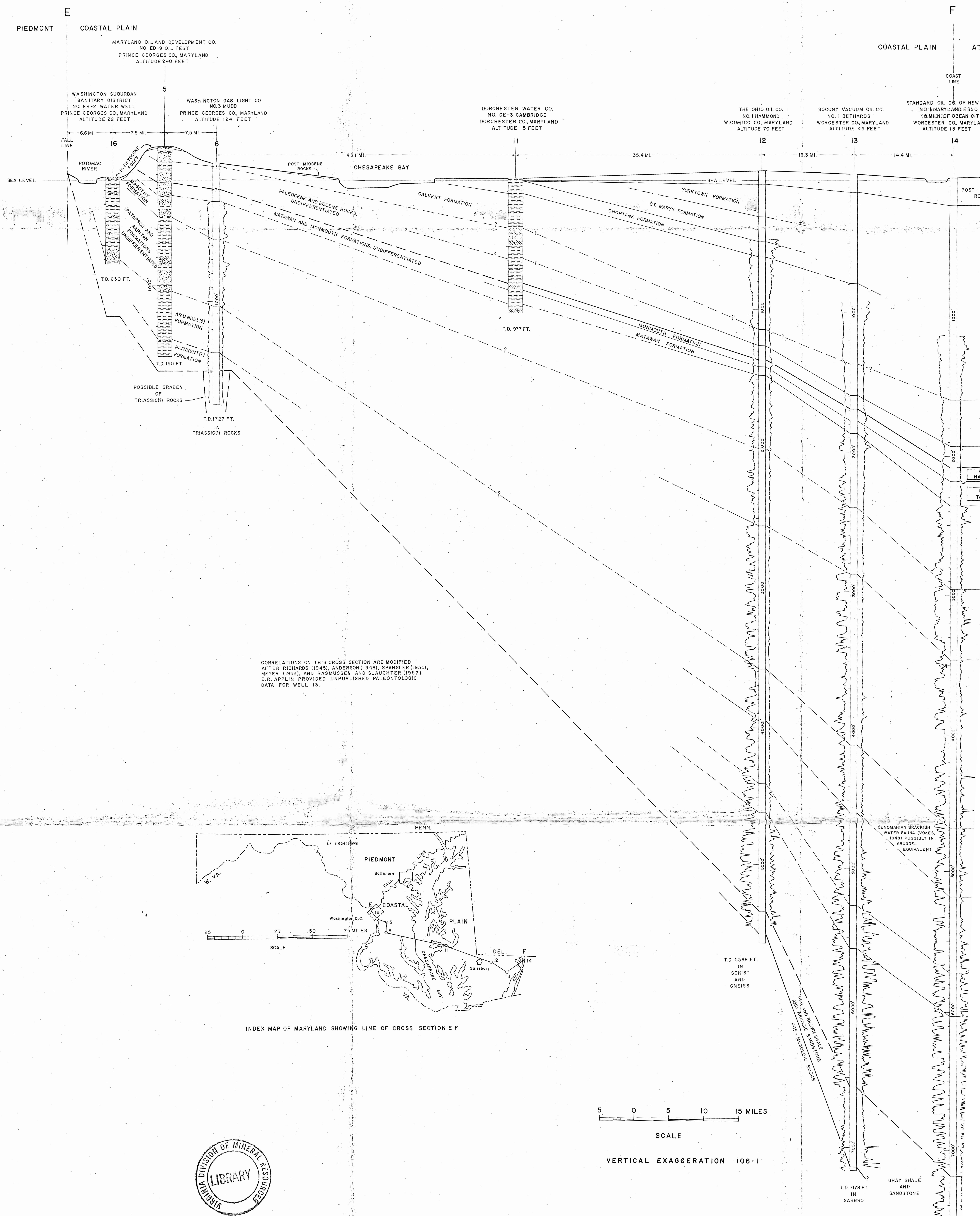
PL. 8 HIGH-INTENSITY MAGNETIC TRENDS ALONG THE ATLANTIC CONTINENTAL SHELF

PL. 9 GEOLOGIC CROSS SECTION AB OF MESOZOIC AND CENOZOIC ROCKS FROM FLORIDA KEYS TO LONG ISLAND

BY

John C. Maher

1964



CORRELATIONS ON THIS CROSS SECTION ARE MODIFIED AFTER RICHARDS (1945), ANDERSON (1948), SPANGLER (1950), MEYER (1952), AND RASMUSSEN AND SLAUGHTER (1957). E.R. APPLIN PROVIDED UNPUBLISHED PALEONTOLOGIC DATA FOR WELL 13.

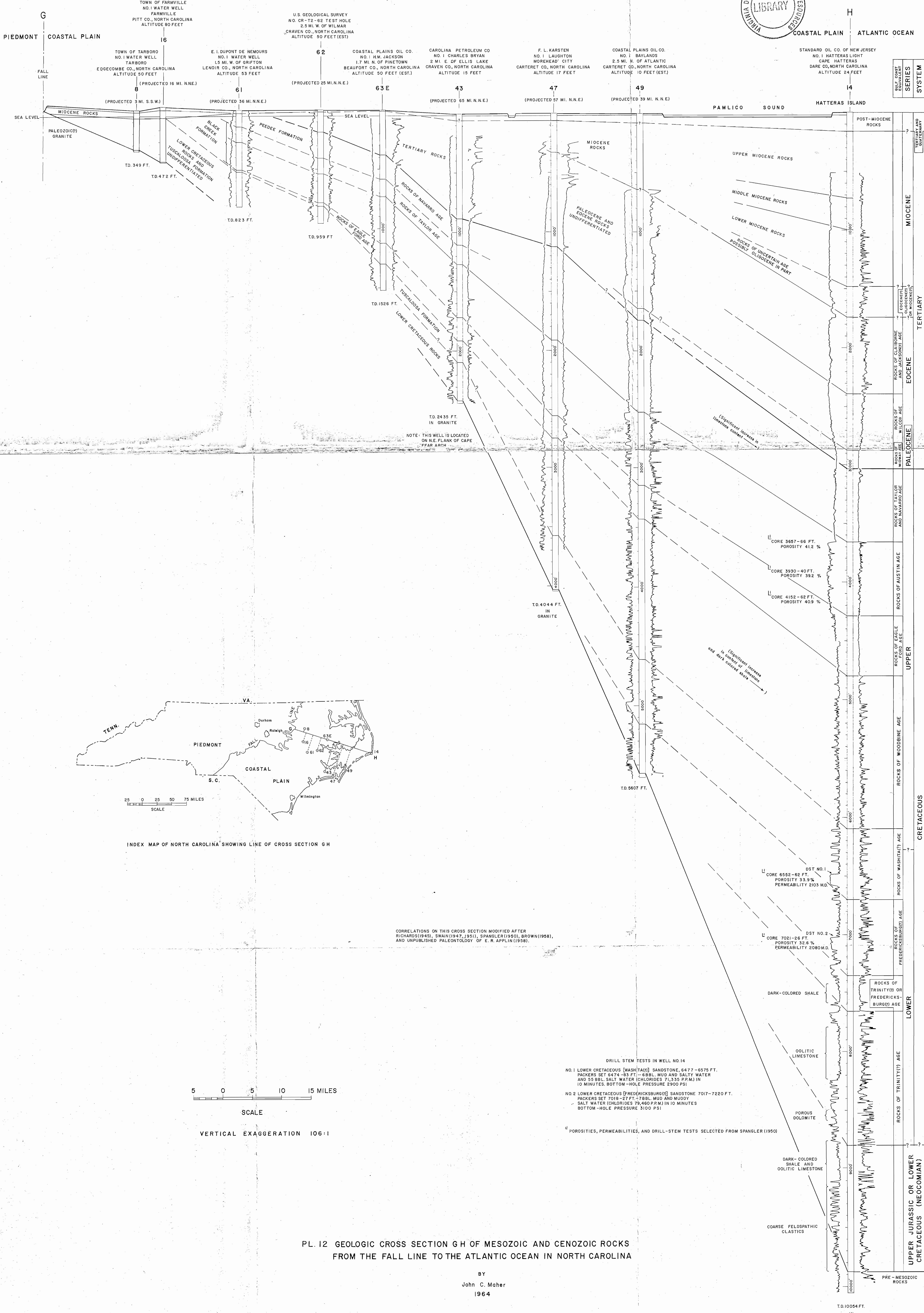
INDEX MAP OF MARYLAND SHOWING LINE OF CROSS SECTION E F

PL. II GEOLOGIC CROSS SECTION EF OF MESOZOIC AND CENOZOIC ROCKS FROM THE FALL LINE TO THE ATLANTIC OCEAN IN MARYLAND

BY

John C. Maher

1964

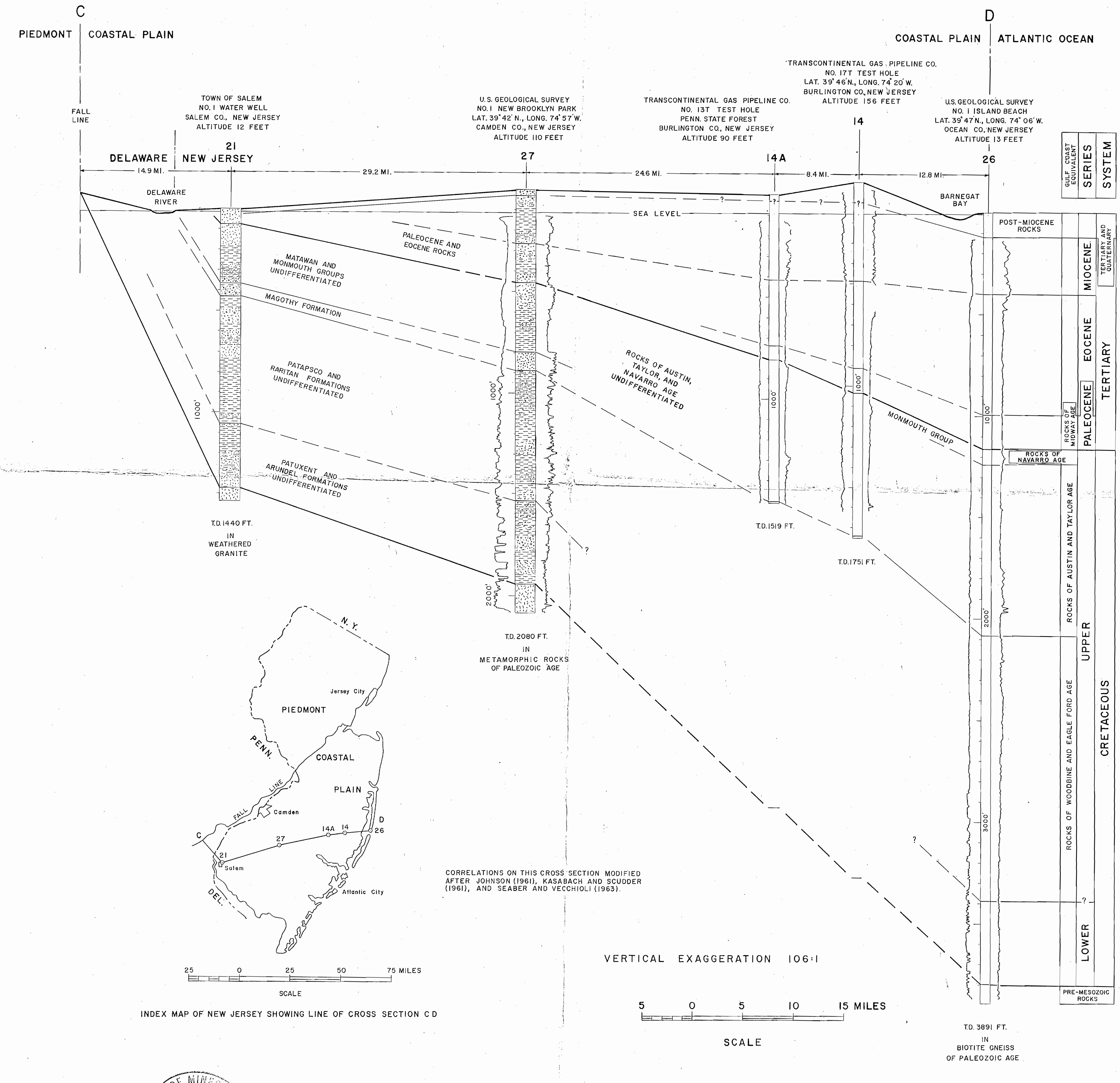


PL. 12 GEOLOGIC CROSS SECTION G H OF MESOZOIC AND CENOZOIC ROCKS FROM THE FALL LINE TO THE ATLANTIC OCEAN IN NORTH CAROLINA

BY

John C. Maher

1964



PL. 10 GEOLOGIC CROSS SECTION CD OF MESOZOIC AND CENOZOIC ROCKS FROM THE FALL LINE TO THE ATLANTIC OCEAN IN NEW JERSEY

BY

John C. Maher

1964

PL. 2 LOCATIONS OF PUBLISHED SEISMIC PROFILES AND BOTTOM SAMPLES ALONG THE ATLANTIC COAST (JANUARY 1, 1965)

Table 2. Stratigraphic units and their Gulf Coast equivalents in wells along the Atlantic Coast

System	Series		Gulf Coast equivalent	Florida units	Georgia units	South Carolina units	North Carolina units	Maryland units	New Jersey units	Long Island units
Tertiary and Quaternary	Pliocene, Pleistocene, and Recent		Post-Miocene rocks	Post-Miocene rocks	Post-Miocene rocks	Post-Miocene rocks	Post-Miocene rocks	Post-Miocene rocks	Post-Miocene rocks	Post-Miocene rocks
	Miocene		Miocene rocks	Miocene rocks	Miocene rocks	Absent on Cape Fear arch	Middle and upper Miocene rocks	Middle and upper Miocene rocks	Eocene and Miocene rocks undifferentiated	Tertiary rocks undifferentiated
							Lower Miocene rocks	Lower Miocene rocks		
Tertiary	Oligocene		Oligocene rocks	Oligocene rocks	Oligocene rocks	Absent on Cape Fear arch	Rocks of uncertain age, possibly Oligocene in part	No Oligocene known		
	Eocene		Rocks of Jackson age	Ocala Limestone	Rocks of Jackson age	Rocks of Jackson age	Middle and upper Eocene rocks	Eocene rocks, undifferentiated		
			Rocks of Claiborne age	Avon Park Limestone Lake City Limestone	Tallahatta and Lisbon Formations, undifferentiated	Paleocene, and lower and middle Eocene rocks, undifferentiated				
			Rocks of Wilcox age	Oldsmar Limestone	Rocks of Wilcox age		Lower Eocene rocks			
	Paleocene		Rocks of Midway age	Cedar Keys Limestone	Clayton Formation		Beaufort Formation	Paleocene rocks	Paleocene(?) rocks	
Cretaceous	Upper	Gulf	Rocks of Navarro age	Rocks of Navarro age	Rocks of Navarro age	Rocks of Navarro age	Pedee Formation	Monmouth Formation	Monmouth Group	Monmouth Group
			Rocks of Taylor age	Rocks of Taylor age	Rocks of Taylor age	Rocks of Taylor age	Black Creek Formation	Matawan Formation	Magothy Formation and Matawan Group, undifferentiated	Magothy Formation and Matawan Group, undifferentiated
			Rocks of Austin age	Rocks of Austin age	Rocks of Austin age	Rocks of Austin age		Rocks of Austin age		
			Rocks of Woodbine and Eagle Ford age	Atkinson Formation	Rocks of Eagle Ford age	Rocks of Eagle Ford age	Rocks of Eagle Ford age	Rocks of Eagle Ford age	Raritan Formation	Raritan Formation
					Tuscaloosa Formation	Tuscaloosa Formation	Tuscaloosa Formation	Rocks of Woodbine age		
?	Lower	Comanche	Rocks of Washita age	Rocks of Washita age	Lower Cretaceous rocks	Lower Cretaceous rocks	Rocks of Washita(?) age	Rocks of Washita(?) age	Rocks of Fredericksburg(?) and Washita(?) age, undifferentiated	Lower Cretaceous rocks absent
			Rocks of Fredericksburg age	Rocks of Fredericksburg age			Rocks of Fredericksburg(?) age	Rocks of Fredericksburg(?) age		
			Rocks of Trinity age	Rocks of late Trinity age Sunniland Limestone Rocks of early Trinity age			Rocks of Trinity(?) or Fredericksburg(?) age	Rocks of Trinity(?) or Fredericksburg(?) age	Rocks of Trinity(?) age and older	
							Rocks of Trinity(?) age	Rocks of Trinity(?) age		
?	Upper Jurassic or Lower Cretaceous (Neocomian)		Upper Jurassic or Lower Cretaceous (Neocomian)	Upper Jurassic or Lower Cretaceous (Neocomian)	Upper Jurassic or Lower Cretaceous (Neocomian) absent	Upper Jurassic or Lower Cretaceous (Neocomian) absent	Mesozoic rocks of uncertain age, possibly Neocomian Cretaceous	Mesozoic rocks of uncertain age, possibly Neocomian Cretaceous		Upper Jurassic or Lower Cretaceous (Neocomian) rocks absent

PL. 4 GENERAL GEOLOGY AND REGIONAL STRUCTURE ALONG THE ATLANTIC COAST