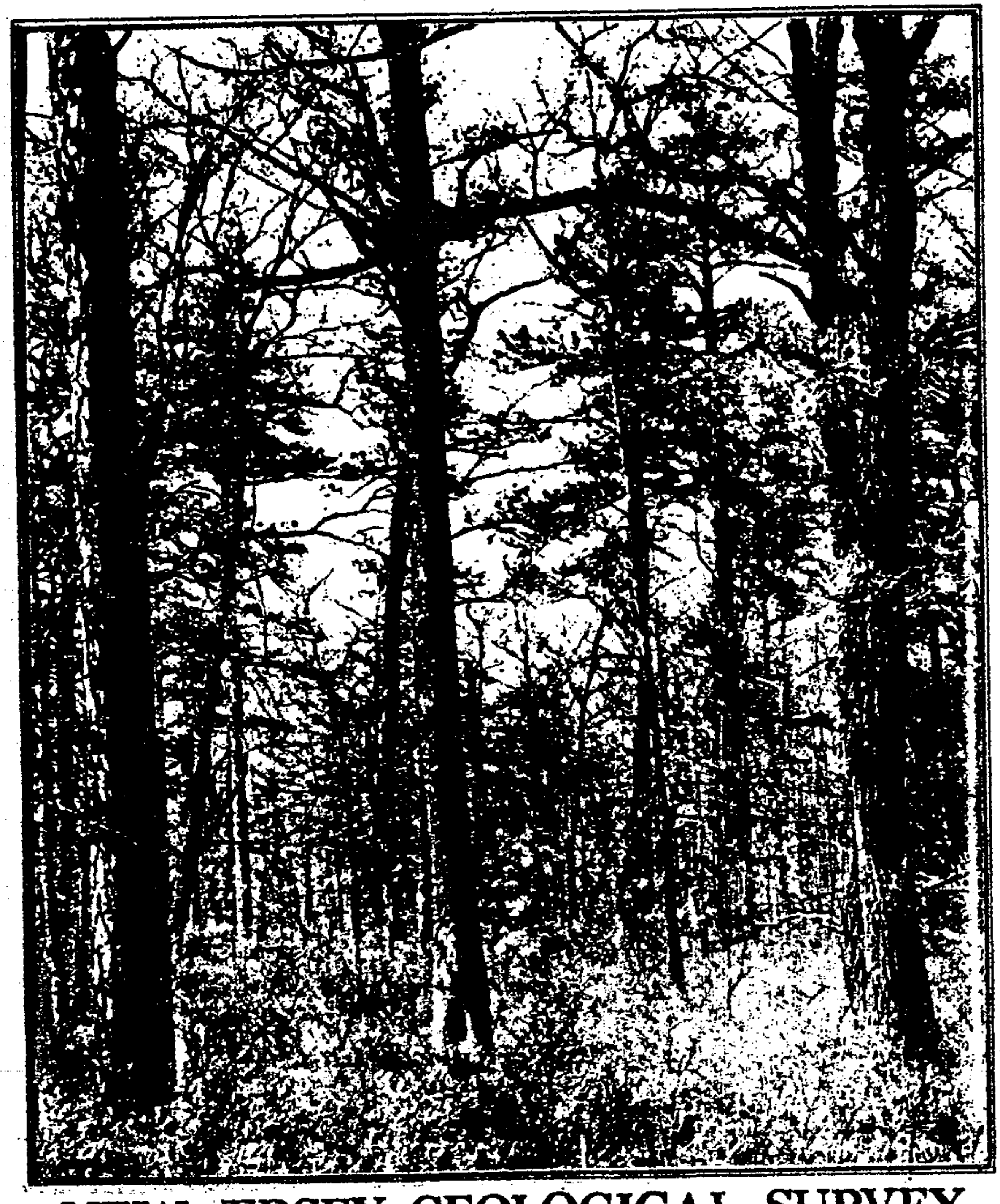
GEOLOGY of ATLANTIC COUNTY in brief



NEW JERSEY GEOLOGICAL SURVEY

STATE OF NEW JERSEY

Department of Environmental Protection
Daniel J. O'Hern, Commissioner
Glenn L. Paulson, Assistant Commissioner

Bureau of Geology and Topography
Kemble Widmer, State Geologist

GEOLOGY OF ATLANTIC COUNTY IN BRIEF

by

Brenda M. H. Jogan
Assistant Geologist

June, 1978

Bureau of Geology and Topography
P.O. Box 1390
Trenton, New Jersey 08625

GEOLOGY OF ATLANTIC COUNTY IN BRIEF

Physiography and General Geology

Atlantic County is within the Atlantic Coastal Plain physiographic province. This province is an eastward thickening apron of unconsolidated and partly consolidated sediments which extends along the east coast from Massachusetts to Florida. The different layers of sediments within the Coastal Plain have been divided into units called formations. A formation is defined as a mappable stratigraphic unit, indicating that it has some characteristics which can be traced over a large area. Formations are not exactly the same at all locations, however. Coastal Plain formations can change in lithology, or sediment type, and thickness both along the outcrop, with depth from the outcrop, and vertically within the formation itself. The outcrop is the area in which a formation is exposed at the surface of the earth. Changes in lithology are indicators of changes in the environment of deposition.

Figure 1 is a geologic map showing outcrop areas for the different formations surfacing in Atlantic County. The cross-section in Figure 2 indicates how younger formations overlie older formations and also shows how most formations in the Coastal Plain thicken toward the southeast. The Geologic Time Scale for Atlantic County in the back of this report gives an overview of all the formations, their place in time, and approximate thickness in Atlantic County.

During the 100 million years while the sediments of the Coastal Plain were being deposited sea level changed many times. It is possible to document these changes in sediment type, or lithology, by observing the sequence of deposits in a vertical section. An advancing sea would encroach, or transgress, upon the land and cover deposits of

GEOLOGIC MAP OF ATLANTIC COUNTY

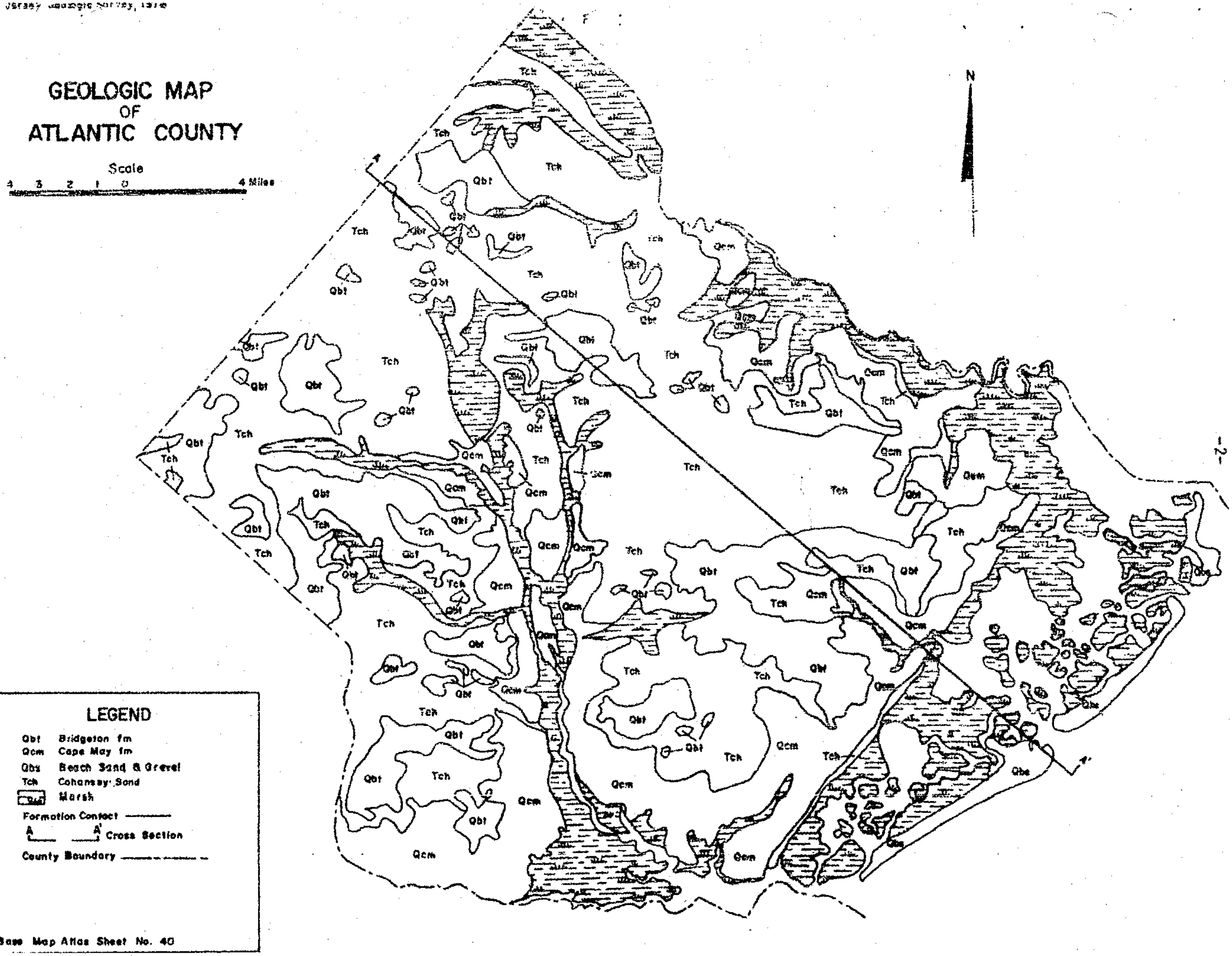
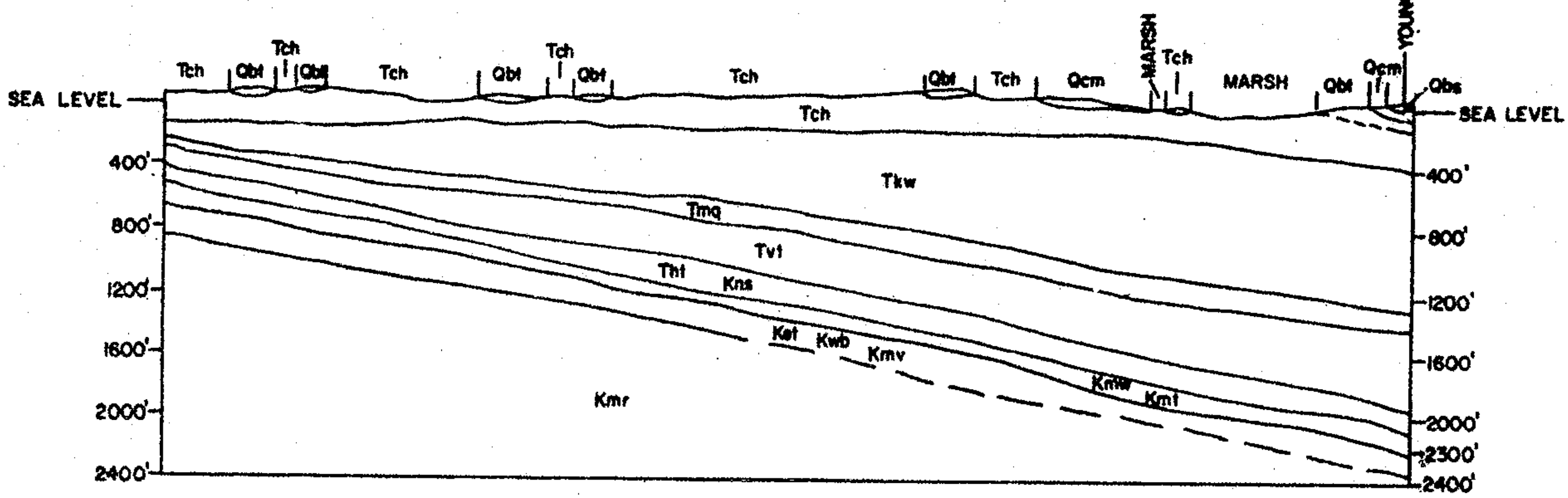


FIG. 2

GEOLOGIC CROSS-SECTION OF ATLANTIC COUNTY



LEGEND

Qbs - BEACH SAND & GRAVEL
Qcm - CAPE MAY
Qbt - BRIDGETON
Tch - COHANSEY
Tkw - KIRKWOOD
Tmq - MANASQUAN / SHARK RIVER
Tvt - VINCENTOWN
Thi - HORNERSTOWN

Kns - NAVESINK
Kmw - WENONAH / MOUNT LAUREL
Kmt - MARSHALLTOWN
Ket - ENGLISHTOW
Kwb - WOODBURY
Kmv - MERCHANTVILLE
Kmr - MAGOTHY / RARITAN

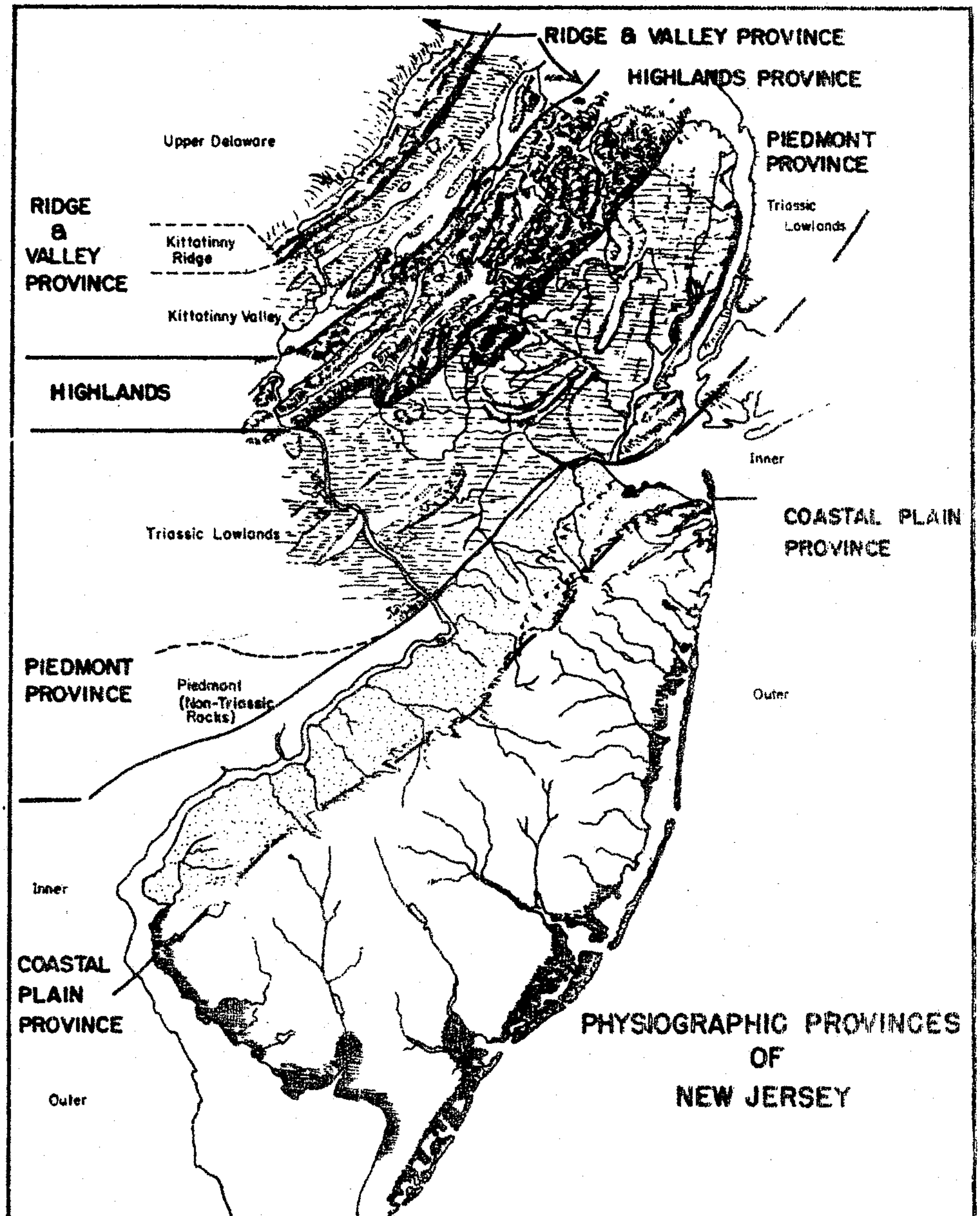
VERTICAL SCALE
½" = 400 Feet

HORIZONTAL SCALE
1" = 4 Miles

river and stream gravel with beach sands and lagoon sediments. As the sea continued to transgress, the beaches and lagoons were in turn covered by the finer sands and clays of deeper waters. Such a sequence of alluvial, or river and stream, deposits covered by shoreline and then deep water sediments represents a transgressive sequence. The same sediments deposited in the reverse order (fine sands and clays, then beach sand, then river gravel) represent a retreat, or regression of the sea from the land and produces a regressive sequence.

The contacts between formations are an important indication of the geologic history of an area. If the contact is gradational from one formation to another, it is said to be conformable. This indicates that depositional conditions were changing gradually with no break in the sedimentary record. A sharp contact indicates an abrupt change in deposition conditions and is known as unconformity. An unconformity is a gap in the geologic record caused by a break in sedimentation: either a formation has been partly or completely removed by erosion or some other major change in the depositional environments has occurred to disrupt the sequence of sedimentation. Unconformities may be distinct, as when the underlying strata are at an angle to the overlying material or when there is evidence of erosion. Indicators of erosion are when the underlying strata has an uneven form or when bits of reworked material from the older layer are included in the younger formation. Unconformities may also be difficult to detect for the formations may remain parallel with only subtle changes in lithology.

New Jersey has four Physiographic Provinces which are illustrated in Figure 3. In New Jersey the Coastal Plain can also be divided into three sub-provinces: the inner lowland (formed by a large river which once


RIDGE & VALLEY PROVINCE
HIGHLANDS PROVINCE
PIEDMONT PROVINCE
Triassic Lowlands
Upper Delaware
RIDGE & VALLEY PROVINCE
Kittatinny Ridge
Kittatinny Valley
HIGHLANDS
Inner
COASTAL PLAIN PROVINCE
Triassic Lowlands
PIEDMONT PROVINCE
Piedmont (Non-Triassic Rocks)
Outer
Inner
COASTAL PLAIN PROVINCE
Outer
PHYSIOGRAPHIC PROVINCES OF NEW JERSEY

flowed there); the inner upland (made up of remnants of Miocene-Pliocene marine beds); and the outer lowland (containing mainly Pleistocene-age deposits). Atlantic County has within its boundaries part of the inner upland and part of the outer lowland.

Precambrian and Paleozoic Geology

The Precambrian and Paleozoic history of Atlantic County is poorly known because the rocks that represent this time period are deeply buried beneath the Cenozoic and Mesozoic sediments. This older rock surface, sometimes referred to as the "basement," was assumed to be very flat in relief, sloping southeastward toward the ocean at a rate of 80 to 100 feet per mile. As each new deep well is sunk, however, the outline of the basement surface is proving to be more and more rugged. The composition of these basement rocks includes crystalline igneous and metamorphic rocks. They are known only from the very few wells which have penetrated the entire thickness of Coastal Plain sediments. None of these wells are in Atlantic County.

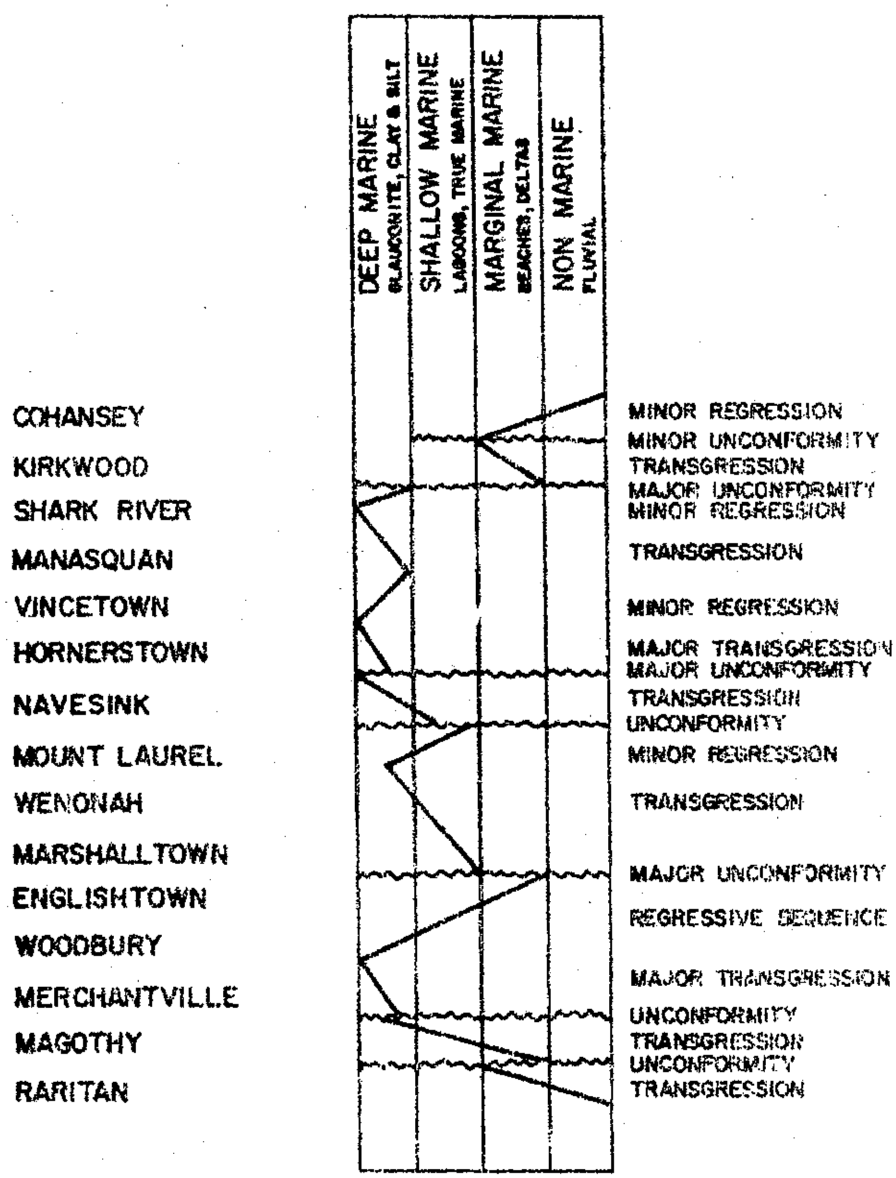
The Geologic Time Scale of Atlantic County on Page 19 illustrates the relationships of the formations found in Atlantic County and their position in time. Figure 4 shows the formations of the Coastal Plain with respect to fluctuations in sea level.

The Mesozoic Era

Triassic and Jurassic

During the Jurassic and early part of Cretaceous times all of what we call New Jersey was eroded to a peneplain surface. Because of this massive erosional period, rocks and sediments of Triassic and/or Jurassic age have not been found at depth, but may exist beneath the Cretaceous sediments in the northern part of the Coastal Plain province of New

FIG. 4



PRE-PLEISTOCENE COASTAL PLAIN FORMATIONS SHOWING ADVANCES AND RETREATS OF SEA LEVEL.

Jersey. In mid-Cretaceous times this peneplain surface began to tilt and warp, causing areas to the southeast to submerge below sea level while the northern areas of the state were uplifted to form a range of hills. Fast running streams in the northeastern hilly region caused erosion and carried sands, silts and clays southeastward to be deposited in the stream channels, bogs and estuaries of the fluctuating shoreline.

Cretaceous

The Raritan Formation, the oldest and thickest of the Coastal Plain formations, is made up of alternating layers of sands and clays. These sediments were deposited in the river channels, flood plains, and deltas of major river systems flowing southeastward across the eroded basement surface. Fossils found in the Raritan Formation are of brackish and marine water members of the clam family. This indicates that during the Cretaceous the position of the shoreline fluctuated but generally advanced northward and westward across New Jersey.

Overlying and unconformable with the Raritan Formation is the Magothy, another transgressive sequence similar to and sometimes grouped with the Raritan. Evidence that the Magothy is transgressive in nature is indicated by the presence of true marine fossils and some glauconite. Glauconite is a green mineral similar to mica which forms on the ocean floor far enough from land so that land-derived sediment will not inhibit the formation of the glauconite grains. Modern glauconite is typically deposited at depths of 100-300 meters and so are used as indicators for an offshore marine environment. Glauconite is also referred to as greensand, and formations which are composed almost entirely of glauconite are called greensand marls.

An unconformity is found between the Magothy and the overlying Merchantville Formation. This break in the sedimentary record is indicated by bits of reworked Magothy material incorporated into the lower part of the Merchantville Formation, as well as a change in sediment type. The Merchantville is a black, glauconitic marine clay and marks a major transgression of the Cretaceous seas upon the land.

Gradational with the Merchantville is the Woodbury Formation, indicating that conditions of depositional processes changed without a break in the sedimentary record. In this case, there was a lowering of sea level, or a regression, which deposited the glauconite-free marine clays of the Woodbury in progressively shallower water.

Sea level continued to drop, allowing marine sediments to grade into lagoon and deltaic sediments. The next formation, the Englishtown, is made up of interlaminated clays and sands representative of a deltaic environment as well as poorly stratified sands and clays with marine fossils which indicate a lagoon or near-shore environment. The Englishtown thus defines the maximum phase of the regression that began during the deposition of the Woodbury.

There is an abrupt change, represented by an unconformity, between the Englishtown and the overlying Marshalltown Formation. A renewed transgression of the sea deposited the black, silty, marine sandy clays of the Marshalltown on top of the Englishtown.

Gradational with the Marshalltown is the Wenonah Formation, a dark, very micaceous, silty fine quartz sand of marine origin. The overlying Mount Laurel Sand is frequently grouped together with the Wenonah because of the close resemblance in lithology, or sediment type. The coarser Mount Laurel Sand was deposited in an environment closer to shore (shallower water) than the finer grained Wenonah, and represents a minor regression of the sea.

Unconformably overlying the Mount Laurel Sand and signifying a readvance of the sea is the Navesink Formation. This is a massive green-gray glauconite sand whose glauconite content diminishes far downdip. This decrease of glauconite content with increasing distance from the outcrop indicates that the water level deepened beyond the existing range in which the glauconite was forming. Consequently, less glauconite was deposited at depth.

The Cenozoic Era

The uppermost two Cretaceous formations, the Red Bank Sand and the Tinton Sand, are not found in Atlantic County. These formations may not have been deposited in the southern Coastal Plain because it is more probable that they were removed during a major regression of the sea in the early Cenozoic. This drastic withdrawal of the sea exposed the unconsolidated sediments to severe erosional conditions.

A major unconformity was produced by the removal of the Coastal Plain sediments. The plane of this unconformity, when projected northwestward beyond the Coastal Plain, coincides with the flat tops of the various mountains of northern New Jersey. This suggests that much of the present topography of northern and central New Jersey has developed from the removal of the softer rocks, thus forming most of the present valleys. The overlying Tertiary-age deposits on the Coastal Plain are thus, at least in part, made up of material removed from the northern part of the state.

Tertiary

Paleocene

The Hornerstown Sand, or marl, unconformably overlies the Navesink in Atlantic County and marks a major transgression of the sea. Fossil evidence indicates that the basal unit of the Hornerstown may be Cretaceous in age (Woife, 1977), but it is here considered as the earliest Tertiary formation. This is a glauconite-rich formation with small amounts of sand and clay which was deposited in an offshore marine environment.

The overlying Vincentown Formation, with its light colored sands and lower glauconite content, marks a minor regression of the sea with no break in the sedimentary record. This unit is one of the most fossiliferous of the Coastal Plain formations, with many foraminifera and broken bryozoa, echinoids, corals and other marine organisms.

Eocene

The Manasquan Formation conformably overlies the Vincentown in Atlantic County and represents a return to deeper water conditions. This formation is composed of glauconite, fine quartz sand and gray clays.

A mixture of glauconite and light colored sand comprises the Shark River Formation. Sometimes grouped with the Manasquan, this formation has two units. The lower Squankum unit represents a continued transgression of the Tertiary sea, while the upper Toms River unit indicates a minor regression.

Miocene

A major unconformity is found between the Manasquan/Shark River formations and the overlying Kirkwood, indicating that the sea withdrew from southern New Jersey. During this time erosion took place not only on the newly deposited Manasquan/Shark River formations but also on older Tertiary and Cretaceous deposits as well (Wolfe, 1977). This unconformity, like that at the base of the Tertiary, probably represents a time when much of the topography of northern New Jersey was developing.

As the sea advanced again over the eroded surface of the Coastal Plain, the marginal marine to shallow nearshore sediments of the Kirkwood Formation were deposited. Divided into three members, the Kirkwood consists of a basal marine clay unit, a finely laminated clay silt and an upper orange, yellow and white silty sand. This formation reaches a thickness of over 800 feet beneath Atlantic City. A brief regression occurred again after the deposition of the Kirkwood. This is evidenced by the reworked top of this formation where the contact with the overlying Cohansey is visible in outcrop. The unconformity does not appear to persist in areas downdip of the outcrop, indicating that this break in the sedimentary record was not widespread.

The overlying Cohansey Sand comprises the largest surface area of the Coastal Plain. It is veneered in many places, particularly in the Pine Barrens, by the yellow gravels described below. The Cohansey is a deposit consisting of white to yellow sand, often with prominent crossbedding, and occasional sizeable lenses of clay. The depositional environment of the Cohansey varied widely from marginal marine beaches and lagoons to non-marine fluvial or river deposits.

Pliocene

The Beacon Hill Gravel of Pliocene age is not found in Atlantic County. This formation is described in other County in Brief series where the Beacon Hill Gravel is exposed, such as Monmouth County.

Quaternary

Glaciers of the Pleistocene or Ice Age did not reach the Coastal Plain, but they played an important role in the development of the present landscape by changing sea levels and disrupting the drainage pattern of rivers and streams. The Pleistocene Bridgeton Formation is an iron-rich yellow sand and gravel deposit. This unit was deposited by a major river and stream system during glacial and interglacial periods.

The Bridgeton Formation in Atlantic County contains glauconite and quartz derived from other Coastal Plain formations. The Pensauken is believed to have been deposited by a stream system which may have been the southwest extension of the Hudson River. This stream was joined by the Raritan and Delaware Rivers, flowing southwest to deposit the Pensauken in the Perth Amboy-Trenton trough and along the Delaware south of Trenton. Because of the ancestral direction of this river system, the Pensauken was not deposited in Atlantic County.

Youngest of the Ice Age formations, the Cape May Sand is a clean sand and gravel. Found mostly along rivers, streams and the shore at elevations of less than 50 feet, the Cape May Sand was deposited while the sea was at a higher level than the present.

NATURAL RESOURCES OF ATLANTIC COUNTY

Water

A major resource in Atlantic County is the availability of ground water from several excellent aquifers in the Coastal Plain. The Cohansey and Kirkwood Formations can be considered a single hydrologic unit with respect to the ground water resource. These formations are so permeable that rainfall soaks into the ground and moves down to the water table too fast for most plants to use, even though more than four feet of water a year falls as rain or snow. This ability of the sandy Cohansey and upper Kirkwood Formations to drain water away from the surface is one of the principal causes of the development of the distinctive flora of the Pine Barrens.

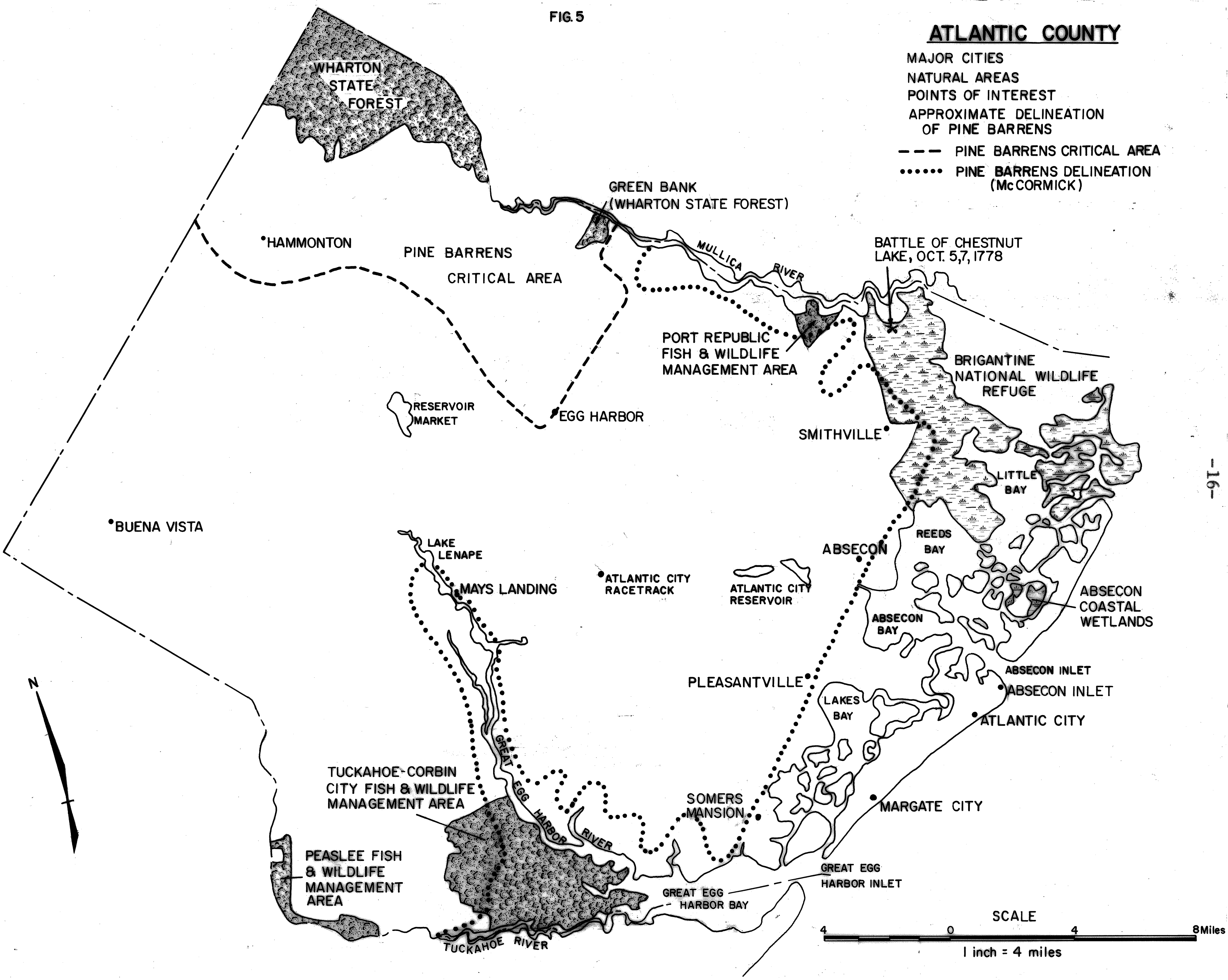
Pine Barrens

All of Atlantic County, except for the tidal marshes, is within the Pine Barrens, a sparsely settled, ecologically unique area covering 1.2 million acres, or one-fourth of the state. Nearly all this area is designated as coniferous forest, with pine trees and scrub oak the dominant tree types. The soils of the area are of an infertile type, called _podzol_ soils, and do not have the ability to decompose organic litter as normal soils do. Consequently, the Pine Barrens is a region of frequent fires. After a fire, new vegetation will sprout from underground roots to continue the cycle of unusual vegetation found in this area. This highly sandy soil is unable to grow most cereal crops, which may account for the name "Barrens" when referring to this region.

Streams in this area are four to five times as far apart as streams in other parts of the state. It should be noted that many of the rivers draining into the Atlantic have the "head of the tide" well inland, almost in the heart of the Pine Barrens. Low elevation (60 feet above sea level) and tidal rivers limit the amount of water taken from wells in parts of the Pine Barrens. Consistently pumping a well to the point where ground water levels are lowered below sea level can result in salt water intrusion regardless of the thickness of the aquifer.

The great permeability of the soil in the Pine Barrens has led in part to the adoption by the state of strict rules and regulations governing the installation and operation of sewerage disposal units, regardless of size. Installation of sewerage facilities in the Pine Barrens requires approval from the state Department of Environmental Protection as a measure to insure that prevailing potable water standards and ground water quality are not endangered by effluent discharge.

FIG. 5


ATLANTIC COUNTY
MAJOR CITIES
NATURAL AREAS
POINTS OF INTEREST
APPROXIMATE DELINEATION OF PINE BARRENS
PINE BARRENS CRITICAL AREA
PINE BARRENS DELINEATION (McCORMICK)
WHARTON STATE FOREST
GREEN BANK (WHARTON STATE FOREST)
MULLICA RIVER
BATTLE OF CHESTNUT LAKE, OCT. 5,7, 1778
HAMMONTON
PINE BARRENS
CRITICAL AREA
PORT REPUBLIC FISH & WILDLIFE MANAGEMENT AREA
BRIGANTINE NATIONAL WILDLIFE REFUGE
RESERVOIR MARKET
EGG HARBOR
SMITHVILLE
LITTLE BAY
BUENA VISTA
LAKE LENAPE
REEDS BAY
ABSECON
MAYS LANDING
ATLANTIC CITY RACETRACK
ATLANTIC CITY RESERVOIR
ABSECON BAY
ABSECON COASTAL WETLANDS
ABSECON INLET
ABSECON INLET
PLEASANTVILLE
LAKES BAY
ATLANTIC CITY
N
GREAT EGG HARBOR RIVER
TUCKAHOE-CORBIN CITY FISH & WILDLIFE MANAGEMENT AREA
SOMERS MANSION
MARGATE CITY
PEASLEE FISH & WILDLIFE MANAGEMENT AREA
GREAT EGG HARBOR INLET
GREAT EGG HARBOR BAY
TUCKAHOE RIVER
SCALE
4 0 4 8Miles
1 inch = 4 miles

ATLANTIC COUNTY'S MINERAL RESOURCES IN BRIEF

Bog Iron

A famous and interesting mineral resource is the bog iron deposits of the Pine Barrens. Mined since colonial times until about 1868, bog iron is found in the marshes and swamps bordering the principal tributaries of the Mullica and Wading Rivers. A belt extending from Atsion in Ocean County along the Mullica, Sleeper Branch, and Nescochague Creek to Landing Creek produces the best bog iron ore. Bog iron begins forming as water, passing through iron-rich clays and sands, picks up oxides of iron. Carbonic acid, essential to retain iron in the dissolved state, is lost when the water comes into contact with the open air. The iron oxides are quickly precipitated along the banks and flood plains of the streams. Tree trunks and stumps have been completely replaced by iron oxides which have preserved in minute detail the original structure of the tree.

Bog iron is unusual because it is a renewable metallic mineral resource. That is, if an area depleted of its ore is left to return to its natural state, bog iron would continue to be deposited and could be "re-harvested" in 20 to 30 years. The high concentration of sulphur and phosphorus in bog iron made it unsuitable for the processing of steel. Other sources of high grade iron ores have made the mining of bog iron unprofitable because of the difficulties in working the bogs and the limited size of the ore bodies.

Sand and Gravel

Among the most widely used of the county's natural resources are the sand and gravel deposits for fill, driveways, and cement aggregate. In several localities the quartz sand of the Cohansey is so pure that it can be used in the production of glass.

GEOLOGIC TIME SCALE

Geologic time intervals are unequal subdivisions of the earth's history corresponding to earth's geologic events. Eras are the longest divisions of time and contain many periods which are further subdivided into epochs. Formations, which are mappable units of rock or sediments, usually have lithology or characteristic distinctions and are assigned to that period or epoch during which they are formed.

A formation's place within the stratigraphic column is determined by the predominant form of life preserved as fossils within the rocks or sediments. If fossils are lacking, a formation's location in the time scale may be determined by its relationship to previously dated units. Only recently have geologists been able to place an absolute date on these relative time units by radioactive methods.

The geologic column is used throughout the world, although some regional modifications may be used for greater clarity.

In the accompanying stratigraphic column, the rock type given after the name is the most common variety found in the county. There may be variation of lithology within the formation from place to place.

GEOLOGIC TIME SCALE OF ATLANTIC COUNTY

Era	Period	Epoch	Formation and Approximate Thickness	Approx. Age Million Years before Present
CENOZOIC	Quaternary	Recent	Soil and alluvium	0-1
		Pleistocene	Cape May Formation (0-90) Bridgeton Formation (0-35)	
	Tertiary	Pliocene (?)	Beacon Hill - Not present in county	1-70
		Pliocene (?) and Miocene	Cohansey Sand (140-260)	
		Miocene	Kirkwood Formation (325-850)	
		Eocene	Manasquan/Shark River (25-200)	
		Paleocene	Vincentown Formation (80-460) Hornerstown Sand (40)	
MESOZOIC	Cretaceous		Red Bank/Tinton Sand - Not present in county Navesink Formation (30-80) Winonah/Mt.Laurel (80-160) Marshalltown (40-60) Englishtown (50-90) Woodbury Clay (50-70) Merchantville (60-100) Magothy/Raritan 1,000+	70-135
	Jurassic		Not present in county	135-180
	Triassic		Not present in county	180-225
PALEOZOIC	Permian Carboniferous Devonian Silurian	- - - - ? - - - -	Not present in county - - - - - ? - - - - - - - - ? - - - -	225-600
	Ordovician Cambrian		Not present in county	
PRECAMBRIAN			Pre-Cretaceous "basement" Age and thickness uncertain	600+

SELECTED REFERENCES

Isphording, W. C. and Lodding, W., 1969, Facies changes in sediments of Miocene age in New Jersey, in Subitzky, S. (ed.), Geology of selected areas in New Jersey and Eastern Pennsylvania: New Brunswick, Rutgers University Press, p. 7-13

Kummel, H. B., 1940, The Geology of New Jersey; New Jersey Department of Conservation, Geological Survey Bulletin #50

Owens, S. P. and Sohl, N. F., 1969, Shelf and deltaic paleoenvironments in the Cretaceous-Tertiary formations of the New Jersey Coastal Plain, in Subitzky, S. (Ed.), Geology of selected areas in New Jersey and Eastern Pennsylvania: New Brunswick, Rutgers University Press, p. 235-278

Wolfe, Peter E., 1977, The geology and landscapes of New Jersey: New York, Crane, Russak & Co., 351 pp.

BOOKS OF INTEREST AVAILABLE FROM THE BUREAU OF GEOLOGY

Widmer, Kemble, 1964, The Geology and Geography of New Jersey; Princeton D. Van Nostrand, V. 19, 193 pp.

County Series:

- Geology of Bergen County in Brief by Carol S. Lucey, Sr.Geologist
- Geology of Burlington County in Brief by K. Widmer and C. S. Lucey
- Geology of Essex & Union Counties in Brief, by C.S.Lucey, Sr.Geologist
- Geology of Hunterdon County in Brief, by Carol S. Lucey, Sr.Geologist
- Geology of Mercer County in Brief by Kemble Widmer, State Geologist
- Geology of Monmouth County in Brief by Carol S. Lucey, Sr.Geologist
- Geology of Morris County in Brief by Carol S. Lucey, Sr.Geologist
- Geology of Passaic County in Brief by David P. Harper, Sr.Geologist
- Geology of Somerset County in Brief by Debra Tobiassen,Asst.Geologist
- Geology of Sussex County in Brief by Carol S. Lucey, Sr.Geologist
- Geology of Warren County in Brief by Carol S. Lucey, Sr.Geologist

ABOUT THE COVER

The 1.2 million acres, or one-fourth of New Jersey, which is known as the Pine Barrens is located above the sandy Cohansey and Kirkwood Formations on the outer Coastal Plain. These sands are so permeable that rain almost immediately moves down to the water table, making it impossible to grow most crops. Pine and scrub oak forests with stands of hemlock and white cedar cover the area. Holly trees, magnolias, wild blueberries and wild cranberries are common.

The dry, sandy soils foiled settlers' attempts to plant crops and perhaps this is why the area is called the "Barrens." In colonial times the region did provide naval stores, wood for the fireplaces of Philadelphia, and charcoal for the bog iron industry. The Barrens was also a famous hangout for thieves and cutthroats who preyed on travelers and merchants using the few roads available during the time of the Revolution.

The New Jersey State Museum Publications Office, 205 West State St., Trenton, NJ, 08625, can provide ecological reports on the Pine Barrens for purchase.

Photograph by Jack McCormick