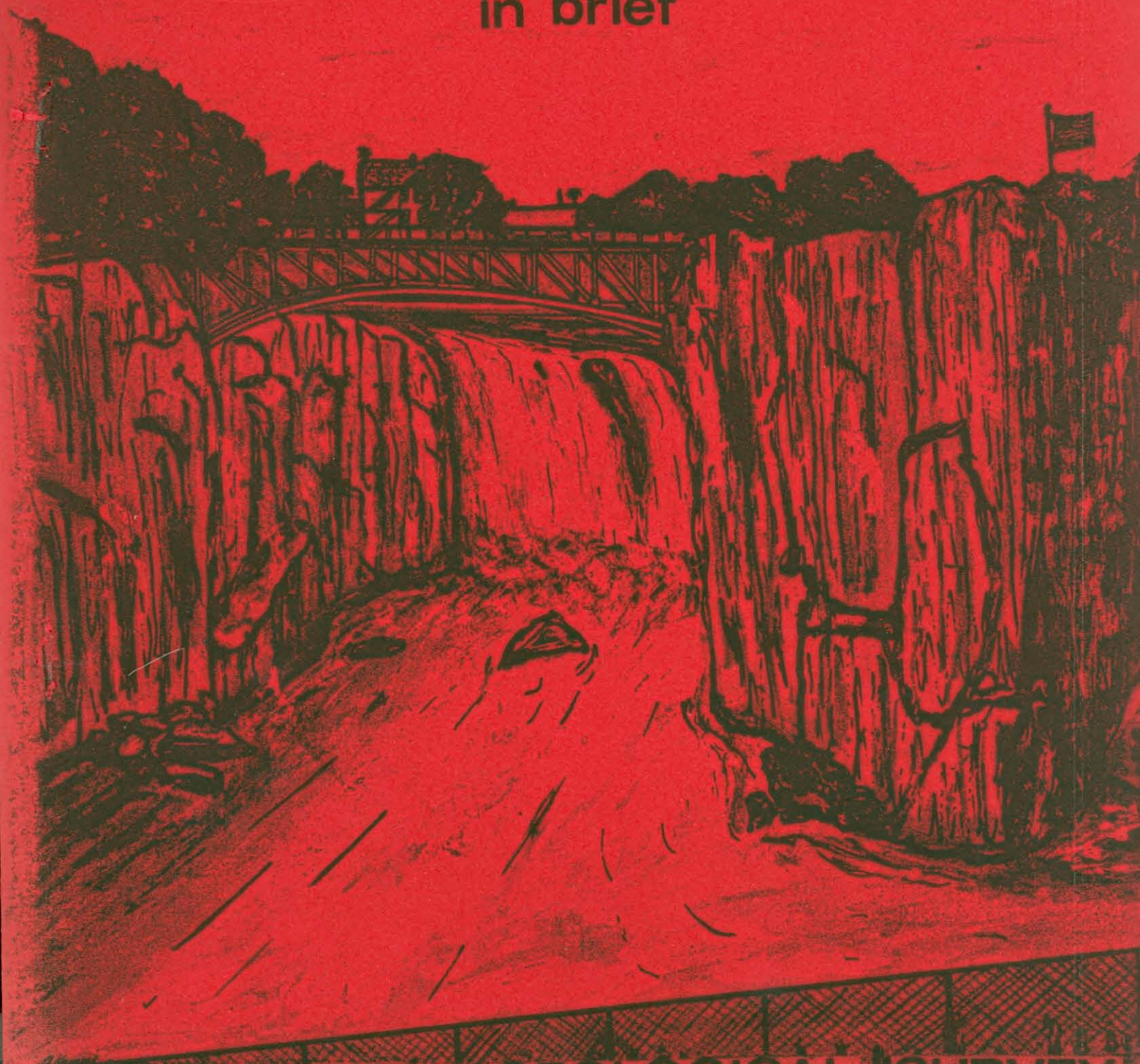
# GEOLOGY
## of
# PASSAIC COUNTY
## in brief



NEW JERSEY GEOLOGICAL SURVEY

STATE OF NEW JERSEY

Department of Environmental Protection
Rocco D. Ricci, Commissioner
Glenn L. Paulson, Assistant Commissioner

Bureau of Geology and Topography
Kemble Widmer, State Geologist

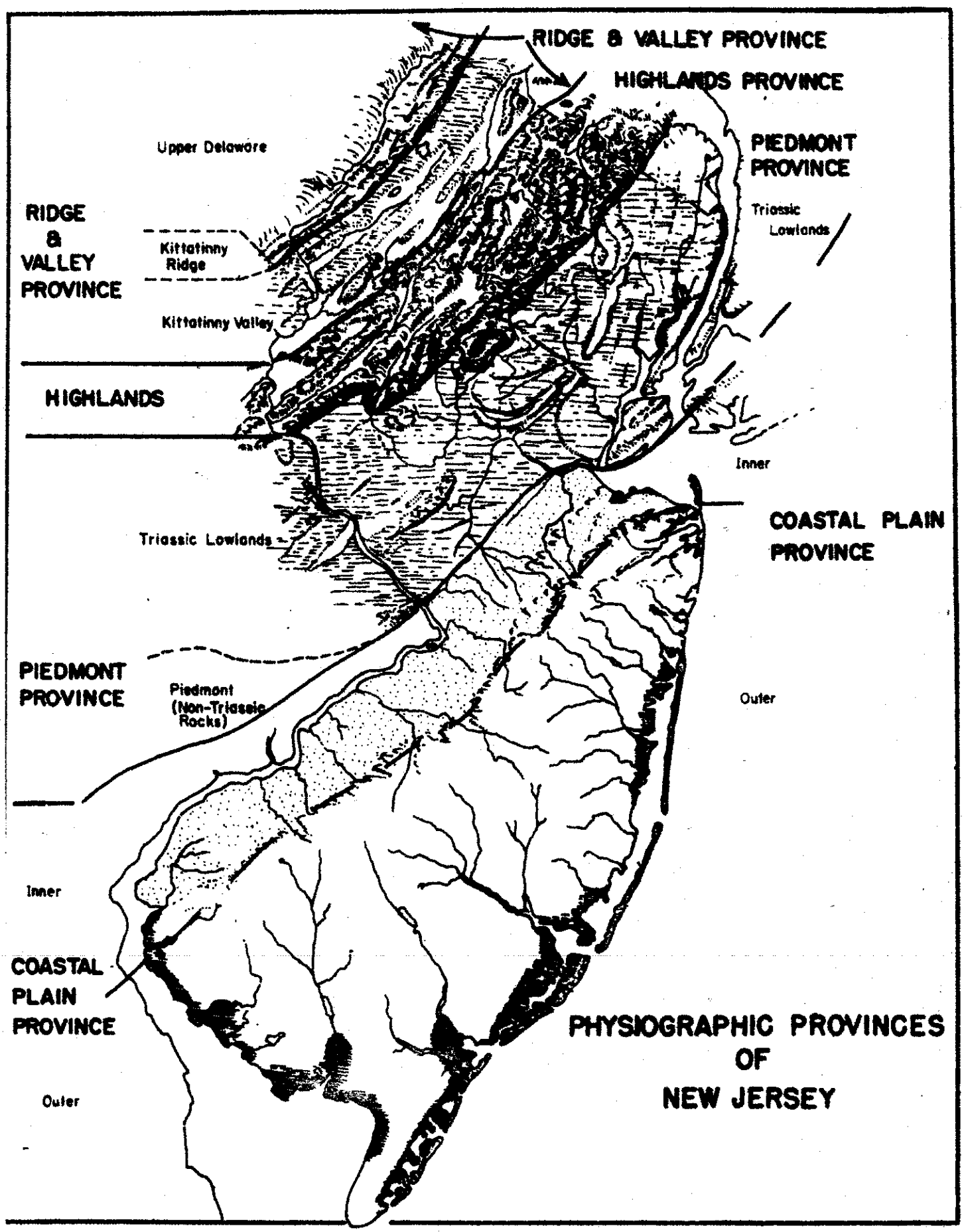
# GEOLOGY OF PASSAIC COUNTY IN BRIEF

by

David P. Harper
Senior Geologist

1977

Bureau of Geology and Topography
P.O. Box 2809
Trenton, New Jersey 08625


RIDGE & VALLEY PROVINCE
HIGHLANDS PROVINCE
PIEDMONT PROVINCE
Upper Delaware
Triassic Lowlands
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

# GEOLOGY OF PASSAIC COUNTY IN BRIEF

## Topography

Passaic County lies within two physiographic provinces. Areas to the northwest of Pompton Lakes are within the New Jersey Highlands section of the New England Physiographic Province. Areas to the southeast of Pompton Lakes are within the Piedmont Province.

The Highlands section of Passaic County (see Physiographic Provinces of New Jersey) includes ridges underlain by Precambrian gneisses, granites, and marbles, and valleys underlain by Paleozoic limestones, sandstones, and slates. The Precambrian rocks are relatively resistant to erosion and, therefore, form a rugged topography.

The Piedmont portion of Passaic County is underlain by volcanic and sedimentary rocks of Mesozoic age. Ridges (for example, Garret and Hook Mountains) consist of resistant basalt formed from cooled volcanic lava. The lowlands are underlain by easily eroded red sandstones and shales. The erosion of these tilted layers of alternately resistant and easily eroded rock is responsible for the distinct ridge and valley topography.

Within the Highlands area, the elevation of ridges averages about 1,100 feet. In the Piedmont, ridges average about 500 feet in elevation. The highest point in the county, Bearfort Mountain, has an elevation of 1,490 feet. In the Highlands the elevations of valleys range from 800 to 300 feet above sea level. In the Piedmont valley floors are at elevations of about 150 feet upstream from the Great Falls of the Passaic River. Below the Great Falls, the valleys have an average elevation of about 50 feet.

## Geologic History

### Precambrian Era

Most of the Precambrian rock of Passaic County was once sediment (sand,

mud, or lime). A small proportion was formed from igneous materials (molten rock which cooled beneath the earth's surface as intrusive magma or erupted from a volcanic vent as lava. Metamorphism (physical and chemical change) was caused by heating and compression that occurred over a long period of time. Limestones became marbles. Sands, muds, and igneous materials were changed to a variety of hard, coarsely granular rocks known as gneisses. Metamorphism took place approximately 840 million years ago. This has been determined by the ratio of radioactive minerals to their decay products (radiometric dating).

On the Geologic Map of New Jersey #40, scale 1:250,000, the Precambrian of the Highlands is divided into the Byram, Losee, and Pochuck gneisses and the Franklin marble. The identification of the Franklin marble is still retained but more modern mapping of the gneisses is based on the mineral composition of the specific gneisses, thus making the terms Byram, Losee, and Pochuck obsolete. For details of the type of gneisses to be found in the Highlands one should refer to the mile-to-the-inch geologic overlays available from the New Jersey Bureau of Geology and Topography.

Fossils have not been reported in Passaic County, although primitive forms of life existed during the Precambrian Era. Graphite, a mineral composed of carbon, has been found in New Jersey marbles and gneisses and is believed to be a remnant of hydrocarbons produced by early forms of life.

## Paleozoic Era

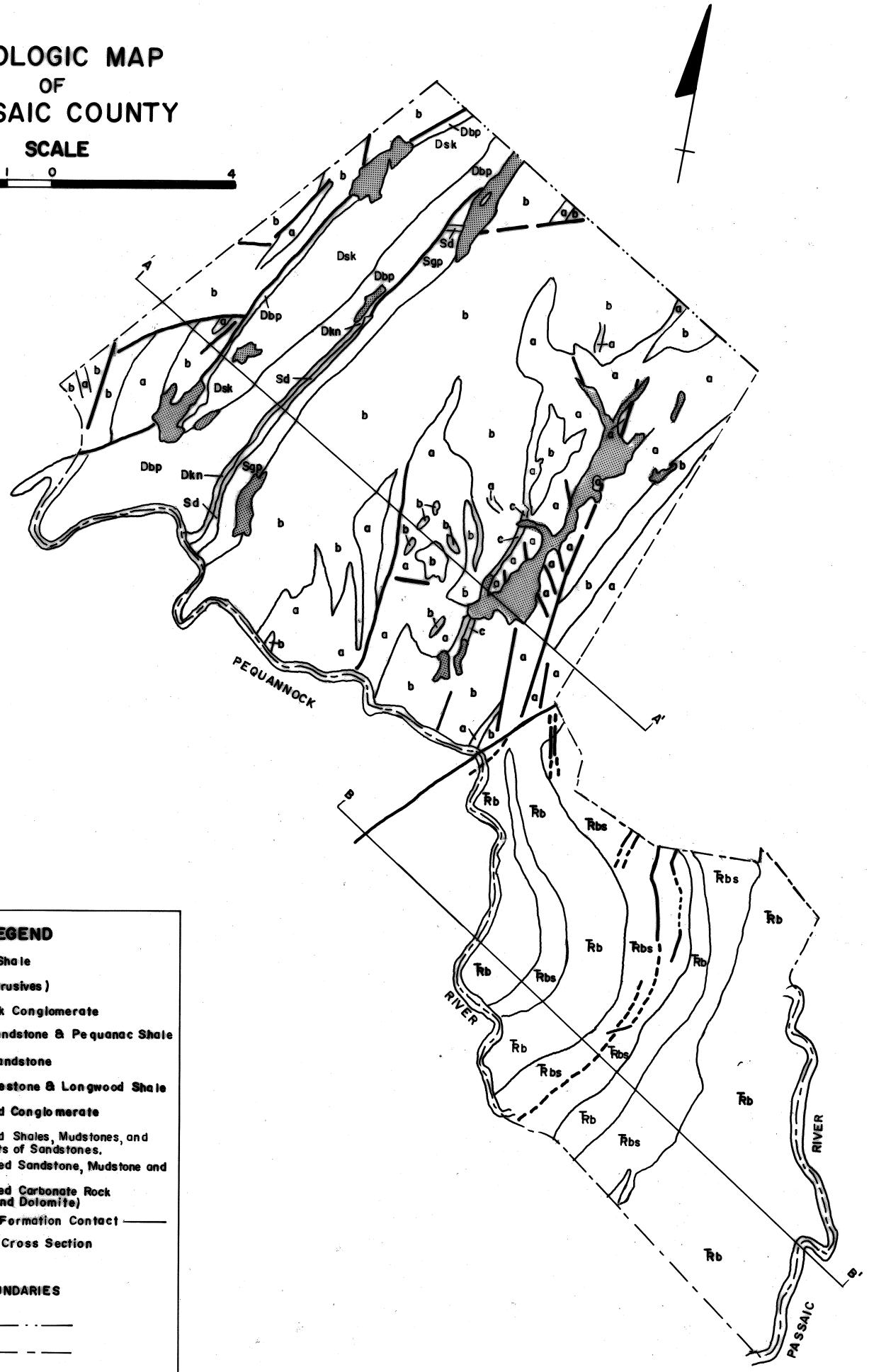
The early Paleozoic formations described below are represented in Passaic County by only a small number of outcroppings which occur in a line from Greenwood Lake to Macopin Lake. The description of these rocks, which are better exposed in the Kittatinny Valley to the northwest, is

New Jersey Geologic Survey 1977

# GEOLOGIC MAP OF PASSAIC COUNTY

SCALE

4 3 2 1 0 4




## LEGEND

Trb — Brunswick Shale

Trbs — Basalt (Extrusives)

Dsk — Skunnemunk Conglomerate

Dbp — Bellvale Sandstone & Pequanac Shale

Dkn — Kanouse Sandstone

Sd — Decker Limestone & Longwood Shale

Sgp — Green Pond Conglomerate

a — Metamorphosed Shales, Mudstones, and minor amounts of Sandstones.

b — Metamorphosed Sandstone, Mudstone and Shale.

c — Metamorphosed Carbonate Rock (Limestone and Dolomite)

Fault ——— Formation Contact ———

A ——— A' Cross Section

Lakes

BOUNDARIES

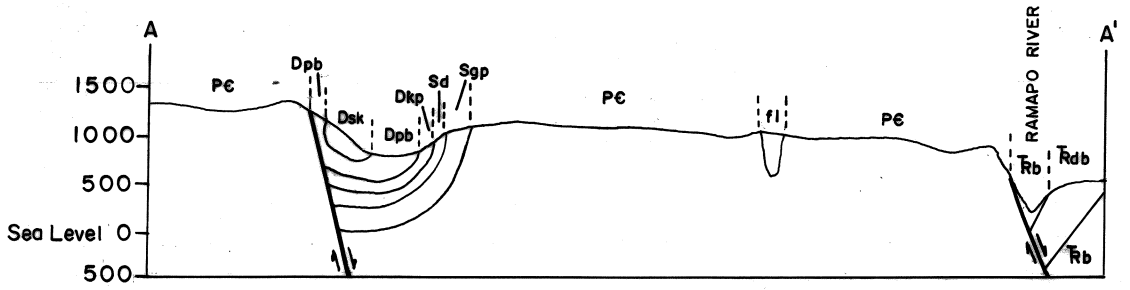
State ——— · ——— · ———

County ——— – ——— – ———

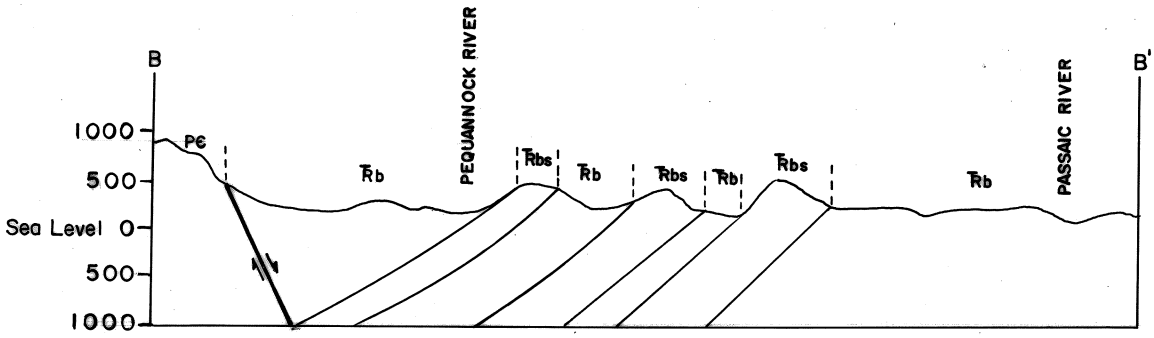
Base Map N.J. Bureau of Geology
Geologic Overlay Series

# GEOLOGIC CROSS SECTIONS
# OF
# PASSAIC COUNTY

New Jersey Geological Survey, 1977




## SECTION A—A'




## SECTION B—B'

## LEGEND

Rb — Brunswick Shale

Rbs — Basalt (Extrusives)

Dsk — Skunnemunk Conglomerate

Dbp — Bellvale Sandstone & Pequanac Shale

Dkn — Kanouse Sandstone

Sd — Decker Limestone & Longwood Shale

Sgp — Green Pond Conglomerate

fl — Franklin Limestone

Pε — Precambrian Age Gneisses

Fault ——— Formation Contact ———

**Horizontal Scale: 1" = 3 Miles**

**Vertical Scale: 1" = 2000 Feet**

given below in order to outline the events which preceded the deposition of the more extensive middle-Paleozoic rock formations which appear infolded in the Green Pond Valley.

Cambrian and Ordovician Periods

The oldest Paleozoic rocks in New Jersey are quartzite and conglomerate of the Hardyston Formation of the early part of the Cambrian Period. These materials were eroded from Precambrian rocks and were rounded by streams and on beaches.

Fossils are rare, but trilobite fragments and worm tubes have been found in the Hardyston Formation.

During the latter part of the Cambrian and the beginning of the Ordovician Periods, warm shallow seas covered much of eastern North America. Tropical and subtropical shallow marine conditions permitted the deposition and accumulation of carbonate minerals.

In New Jersey, thicknesses as great as 5,000 feet (1,500 meters) of calcium and magnesium carbonate make up the series of formations known as the Kittatinny Group. There are abundant algal remains but few animal fossils in the Kittatinny. None have been found in Passaic County.

Fossil-bearing limestones known as the Jacksonburg Formation overlie the Kittatinny carbonates in most of New Jersey. In Passaic County, these limestones were removed during a period of uplift and erosion which occurred within the Ordovician Period.

The Martinsburg Formation was deposited on the erosion surface developed on the Kittatinny Group and consists of shales, slates, and thin sandstones. Few fossils have been found in the Martinsburg in Passaic County. Brachiopods (clam-like animals) were found during the construction of the Oak Ridge Reservoir and prove that deposition occurred in a marine environment.

Silurian and Devonian Periods

Mountain building events are known to geologists as orogenies if they are major and widespread and as disturbances if they are minor and local. From the end of the Ordovician Period into the beginning of the Silurian Period mountain building took place along much of the eastern United States during what is known as the Taconic Orogeny. Sands and gravels were eroded by mountain streams and carried across Passaic County from the ancient highlands. These have become rock and are the sandstones and conglomerates of the Green Pond Formation.

The Green Pond Formation is a ridge-forming conglomerate and underlies Kanouse Mountain, Green Pond Mountain, and Copperas Mountain. Large pebbles and easily decomposed minerals indicate that deposition was immediately adjacent to the source of this material, since such materials are quickly destroyed as they are rolled and slid along stream beds. According to geologists, the ancient highlands lay to the east because there is an increase in size and abundance of pebbles and easily decomposed minerals from the west to the east. As erosion of the mountainous are to the east continued, the velocity of the streams and their ability to move pebbles and cobbles was reduced. This resulted in less and less deposition of conglomerates and more sandstone and shale.

The end of the Silurian Period and the beginning of the Devonian Period is characterized by a sequence of formations deposited in shallow marine and nearshore marine environments. Among the rock types present are shales, limestones, sandstones, siltstones, and conglomerates. Bryozoans (moss animals), brachiopods, crinoid (sea lilies), and worm trails have been found in the Devonian formations.

During Middle Devonian time, the Acadian Disturbance, characterized by uplift of mountains to the east, caused the renewed deposition of con-

glomerates. These Middle Devonian conglomerates are within the Skunnemunk Formation. The Skunnemunk Formation underlies Bearfort Mountain in New Jersey and Skunnemunk Mountain in New York. Uplift of mountains during the Acadian Disturbance was gradual. As the mountains grew higher and more rugged, the speed of streams increased and larger size material could be carried. As a result, pebbles are more common near the top of the Skunnemunk Formation than near the bottom.

There are no rocks of Mississippian, Pennsylvanian, and Permian age in New Jersey. It is, therefore, impossible to decipher the specific events of those 125 million years.

Within Passaic County there are several good exposures of folded late Paleozoic sediments. Deformation of these initially flat-layered deposits took place during either the Acadian Disturbance or later, during the Appalachian Orogeny, a major mountain building episode at the close of the Paleozoic era.

Mesozoic Era

The southern half of Passaic County is underlain by sediments deposited in a Mesozoic valley known as the Newark-Gettysburg Basin. The basin extends from southern New York into Pennsylvania. The total thickness of Mesozoic rocks deposited in the basin exceeds 5,000 feet (1,500 meters). During this era, there was volcanic activity represented by Garrett Mountain, High Mountain, and Hook Mountain. These three ridges are extensions of the Watchung Mountains and record three major periods of eruption during which lava spread across much of central New Jersey. These lavas are famous for their zeolites, amythyst, calcite, and related minerals deposited in cavities formed by expansion of steam when the rock was still molten. An excellent collection of specimens from Passaic County is on display at the Paterson Museum.

Sedimentary rocks underlie the valleys between the basaltic ridges and were formed by the sands, gravels, and clays that washed in from a highland area to the west. Broad, shallow lakes occupied the bottom of the valley. Many of the sediments are red because they were stained by small amounts of iron oxide.

Fossil fish, crustaceans, reptile bones, dinosaur tracks, and plants have been found in New Jersey's Mesozoic sediments. Dinosaur tracks from Passaic County are on exhibit at the Paterson Museum.

## Cenozoic Era

During the early part of the Cenozoic Era there was a protracted period of erosion. By the end of the Miocene Period (13 million years ago) the land had become almost a flat plain (or peneplain). Uplifting then caused erosion of the softer rocks and formed valleys. The more resistant rocks were little affected by erosion and remained as ridges. The tops of these ridges define a flat surface known as the Schooley Peneplain. The peneplain is a remnant of the Miocene erosion surface. In Passaic County the elevation of this surface varies from about 600 feet (200 meters) above sea level in the southeast where uplift was least to 1,400 feet (427 meters) in the northwest where uplift was greatest.

## The Ice Age

Major glaciers advanced into the northern United States at least four times during the last 20 million years. The latest advance was the Wisconsin Glaciation. It extended completely across Passaic County and obliterated the evidence of previous glaciations.

The glaciers loosened soil and rock from the surface of Passaic County and carried the material elsewhere. The sand and stones embedded in the base of the moving glaciers scoured and polished the bedrock surfaces.

Polished bedrock surfaces are well exposed in Garrett Mountain Reservation.

Deposition of materials eroded by the glaciers occurred primarily to the south of the county, forming the terminal moraine (a ridge of heterogeneously mixed sand, clay, and stones) which marks the southernmost limit of the ice advance. Recessional moraines (ridges formed during retreat of the glacier) and ground moraines (material deposited from the base of the moving glacier) are found in Passaic County. They are made of heterogeneous mixtures of sand, clay, and stones. Meltwater streams reworked the sediments and removed silt and clay. Clean sand and gravel deposited by these streams is referred to as stratified drift and is common in larger valleys within Passaic County.

Silt and clay were deposited in numerous glacial lakes. These lakes were formed when northward flowing streams were blocked by southward moving ice, by meltwaters ponded behind moraines, or by flooding of depressions excavated in the bare rock by the moving ice. Large glacial lakes reached the borders of Passaic County, but covered very little of its area. Lake Passaic, ponded behind the Watchung Mountains, covered in excess of 150 square miles, centered in the Great Swamp, Hatfield Swamp, and Great Piece Meadows areas of Morris and Essex Counties. Lake Hackensack covered in excess of 50 square miles, centered in the Hackensack Meadowlands and the lower Hackensack and Passaic Valleys. Numerous smaller lakes existed in depressions left by the melting ice in Passaic County. These have become filled with silt and plant debris and are now marshy lowland areas.

## Origin of the Great Falls of the Passaic River

The Great Falls of the Passaic River originated in a manner similar to Niagara Falls by the undermining of a layer of hard rock by erosion of an underlying layer of softer rock. In the case of the Great Falls, turbulent,

sediment-charged water eroded soft sandstone, leaving the overlying hard, basaltic rock which forms the First Watchung ridge projecting without support. The present gorge leading to the Great Falls is the result of collapse and erosion along weak rock zones because of closely spaced joints. Erosion at the base of the falls is now wearing away weakened basalt rather than sandstone.

Little Falls, a short distance upstream, marks the point where the Passaic River crosses the basalt of the Second Watchung Mountain. The level of the base of Little Falls cannot be eroded below the crest of the Great Falls. Thus, the Great Falls establishes a temporary base level of erosion.

## MINERAL PRODUCTION IN PASSAIC COUNTY

Mineral production has been an important factor in the economy of Passaic County since the establishment of iron mining at Ringwood before the 1740's and at numerous other locations in the northern portion of the county shortly thereafter. The ore was primarily magnetite from Precambrian rock, with minor production of hematite and goethite from Paleozoic limestones as well. Prior to the development of canals and railroads, most of the ore was smelted locally. Charcoal was used as a fuel. Locally quarried limestone or marble was used as a flux.

Iron mining continued as an important activity through the nineteenth century, but declined early in the twentieth century. The last active iron mine in Passaic County, at Ringwood, closed in the early 1950's.

In addition to iron mining, the production of lime, building stone, trap rock, sand, and gravel have contributed to the position of Passaic County as one of the leading mineral production areas of the state.

Lime, used as a soil conditioner and in cement, has been produced from Precambrian marbles and Paleozoic limestones.

Building stone has been quarried at numerous locations. Brownstone comes from Little Falls, Paterson, and Passaic. Granite comes from several quarries near Pompton.

Many older buildings of northern New Jersey and New York are built with stone from these quarries. Within Passaic County, brownstone from Paterson may be seen at Lambert Castle in the Garret Mountain Reservation. Pompton granite may be seen at Saint Paul's Church, Paterson.

Trap rock (a quarryman's term for basalt and diabase) has been the leading mineral product during most of the present century. The value of trap rock produced each year in Passaic County has been between 5 million

and 10 million dollars through the 1970's. Most trap rock is crushed into gravel-sized pieces for use in construction and road surfacing.

Sand, gravel, and clay are produced from glacial and river deposits.

## SELECTED REFERENCES

Barnett, S.G., 1976, Geology of the Paleozoic rocks of the Green Pond Outlier, New Jersey Geologic Report Series No. 11, 9 pp.

Darton, N.H., and others, 1908, Description of the Passaic quadrangle: U.S.Geol.Survey,Geol.Atlas,Passaic Folio (No.157),New Jersey-New York, 27 pp.

Faust, George T., A review and interpretation of the geologic setting of the Watchung basalt flows, New Jersey, U.S.Geol.Survey Prof. Paper 864-A, 47 pp.

Johnson, M.E., 1950, Geologic map of New Jersey, New Jersey Geological Survey, Atlas Sheet #40, scale 1:250,000 (revision of edition of 1910-1912)

Justus, Philip, editor, 1976, Sourcebook of geologic resource materials and field trips in New Jersey. "The field tripping guide" (2nd edition), Department of Earth Sciences, Fairleigh Dickinson University, 57 pp.

Mason, Brian H., 1960, Trap rock minerals of New Jersey, New Jersey Geologic Survey, Bull.64, Trenton, N.J., 51pp.

Schuberth, Christopher J., 1968, The geology of New York City and environs, Natural History Press, Garden City, N.J. 304pp.

U.S. Bureau of Mines Yearbook, 1977, The mineral industry of New Jersey, U.S. Department of the Interior

## BOOKS OF INTEREST AVAILABLE FROM THE BUREAU OF GEOLOGY

Widmer, Kemble, 1964, The geology and geography of New Jersey, D. Van Nostrand Co., Princeton, N.J., 193 pp.

COUNTY SERIES:

Geology of Bergen County in Brief, Carol S. Lucey, Sr.Geologist
Geology of Burlington County in Brief, K. Widmer and C.S.Lucey
Geology of Essex & Union Counties in Brief, Carol S. Lucey, Sr.Geologist
Geology of Hunterdon County in Brief, Carol S. Lucey, Sr.Geologist
Geology of Mercer County in Brief, Kemble Widmer, State Geologist
Geology of Monmouth County in Brief, Paul B. Dahlgren, Sr.Geologist
Geology of Morris County in Brief, Carol S. Lucey, Sr.Geologist
Geology of Sussex County in Brief, Carol S. Lucey, Sr.Geologist
Geology of Warren County in Brief, Carol S. Lucey, Sr.Geologist

# 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 PASSAIC COUNTY

| Era | Period | Formation or Rock (approx. Thickness) | No. of Million Years Ago |
|---|---|---|---|
| CENOZOIC | Recent<br>Quarternary<br>Pleistocene | Soil and Alluvium<br><br>Glacial Drift<br>0-460 ft.(0-150 m.) | 0-1 |
| | Tertiary | Not present in county | 1-70 |
| MESOZOIC | Cretaceous | Not present in county | 70-135 |
| | Jurassic | Not present in state | 135-180 |
| | Triassic | Brunswick Formation<br>6000-8000 ft.(2000-2700 m.)<br>Basalt (lava flows) | 180-225 |
| PALEOZOIC | Permian | Not present in state | 225-270 |
| | Pennsylvanian<br>Carboniferous<br>Mississippian | Not present in state | 270-350 |
| | Devonian | Bellvale Sandstone<br>1500-2000 ft.(500-700 m.)<br>Pequanac Shale<br>1000 ft.(350 m.)<br>Kanouse Sandstone<br>215 ft.(75 m.) | 350-400 |
| | Silurian | Decker Formation<br>50 ft.(20 m.)<br>Longwood Shale<br>200 ft.(20 m.)<br>Green Pond Conglomerate<br>1200 ft.(400 m.) | 400-440 |
| | Ordovician | Martinsburg Formation<br>3000 ft.(1000 m.) | 440-500 |
| | *Cambro-<br>Ordovician | Kittatinny Dolomite<br>5000 ft.(1700 m.) | |
| | Cambrian | Hardyston Quartzite<br>100 ft.(30 m.) | 500-600 |
| PRECAMBRIAN | | Assorted gneiss and schist ? | 600+ |

*Dashed lines indicate formation was deposited in two time periods.