

GEOLOGY
OF
SUSSEX COUNTY
IN BRIEF

HIGH POINT STATE PARK
WAR MEMORIAL

NEW JERSEY GEOLOGICAL SURVEY

THE MONUMENT

Dominating the summit of the mountain and astride the greatest elevation in New Jersey is High Point Monument. Visible for many miles from vantage points in Pennsylvania, New York and New Jersey, it is an outstanding landmark in Sussex County. Built through the generosity of the late Colonel and Mrs. Anthony R. Kuser, it is dedicated to the "Glory and Honor and Eternal Memory of New Jersey's heroes by land, sea and air in all wars of our country." The 220 foot (73.3 m.) monument, which is 34 feet square (3.2 sq.m.) at the platform, 1,803 feet (578.8 m.) above sea level and tapers to 19 feet (17.4 cm.) at the base of the apex, was started in August, 1928, and was completed in June, 1930. It is faced with New Hampshire granite, with the inner courses of quartzite obtained locally. A nominal fee is charged for admission to the monument. There are steps within the shaft which give access to the top of the structure.

STATE OF NEW JERSEY

Department of Conservation and Economic Development
Robert A. Roe, Commissioner

Division of Resource Development
Kenneth H. Creveling, Director

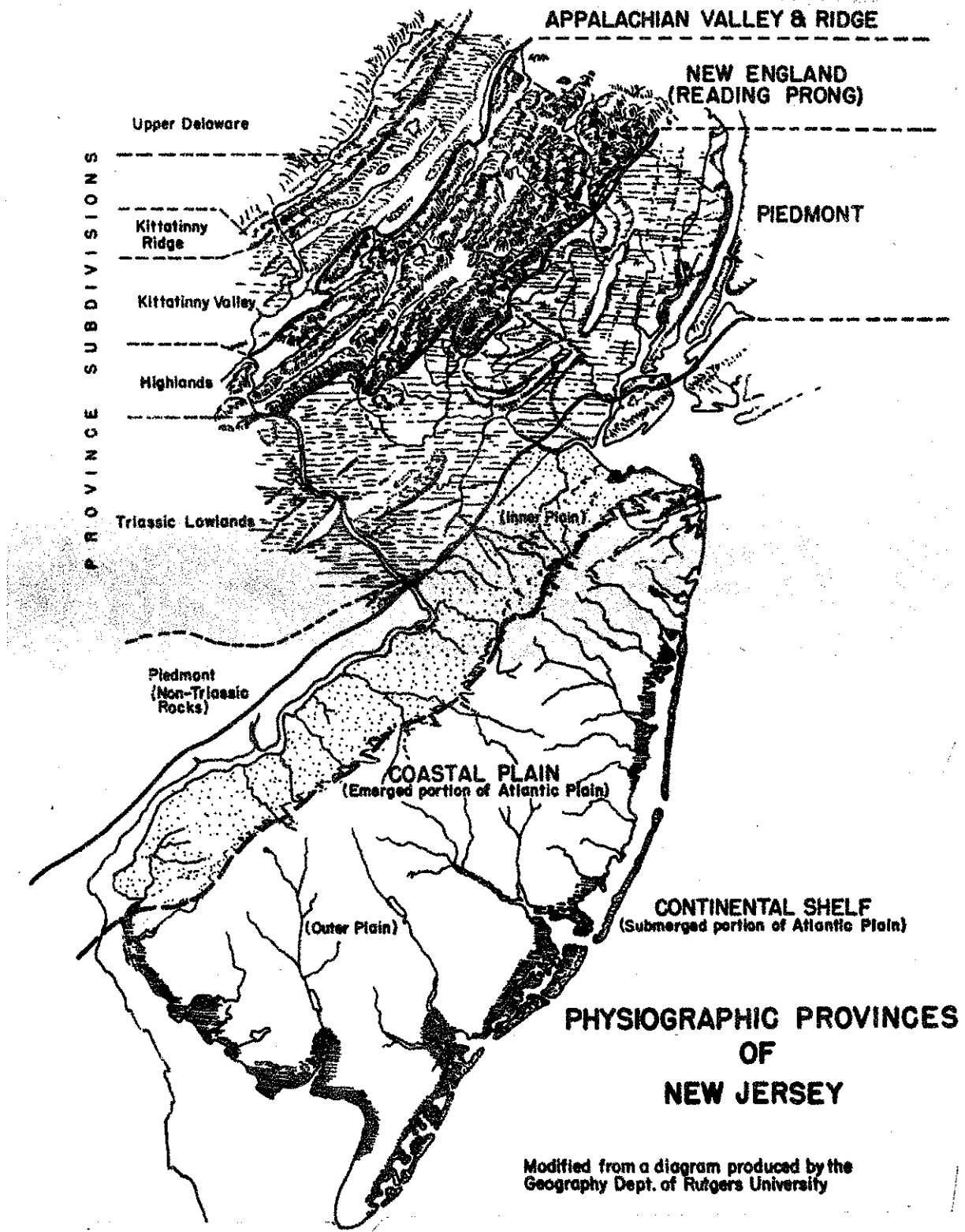
THE GEOLOGY OF SUSSEX COUNTY IN BRIEF

by

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APPALACHIAN VALLEY & RIDGE

NEW ENGLAND
(READING PRONG)

PROVINCE SUBDIVISIONS

Upper Delaware

Kittatinny
Ridge

Kittatinny Valley

Highlands

Triassic Lowlands

PIEDMONT

(Inner Plain)

Piedmont
(Non-Triassic
Rocks)

COASTAL PLAIN
(Emerged portion of Atlantic Plain)

(Outer Plain)

CONTINENTAL SHELF
(Submerged portion of Atlantic Plain)

**PHYSIOGRAPHIC PROVINCES
OF
NEW JERSEY**

Modified from a diagram produced by the
Geography Dept. of Rutgers University

Geology of Sussex County in Brief

Topography

Sussex County lies within two physiographic provinces; the Highlands and the Appalachian Valley and Ridge Province (see Plate I). The Appalachian Valley and Ridge Province, underlain by Paleozoic sedimentary rocks, contains Kittatinny Mountain and the associated valleys. The most prominent ridge is composed of the Shawangunk quartzite and conglomerate, which is very hard and highly resistant to weathering. High Point, which rises 1802.5 feet above sea level, is the highest point in New Jersey and is located on the northwestern part of Kittatinny Mountain. In New Jersey, Kittatinny Mountain is approximately 40 miles long and from one to five miles wide. The valleys are underlain by less resistant shales, dolomites and limestones. The shales are typically very fine grained rocks susceptible to erosion due to fracturing by folding and faulting. The dolomites and limestones are slightly soluble in water and are the least resistant rocks in the valleys.

The New Jersey Highlands are a portion of the Reading Prong of the New England Province. The area consists of a series of ridges, several of which are in Sussex County, and are composed of hard, crystalline, resistant Precambrian igneous and metamorphic rocks. The average elevation of the crests of the mountains is approximately 1000 feet above sea level. The ridges average about 25 miles long and one mile wide in the County.

Geologic History

Proterozoic Era

Precambrian Period - The oldest rocks in the County were originally sedimentary rocks which were deposited in a sea and later altered by a process called metamorphism. Folding and compression deep beneath the earth's

surface provided the necessary heat and pressure to metamorphose or change the rocks. Later, molten igneous rocks intruded the metamorphosed sedimentary rocks causing further alteration. These processes formed metamorphic gneiss, a coarsely grained rock in which bands can be distinguished. Many varieties of gneiss were formed, but they are so closely intermingled they are not separated by name in this report.

The Franklin Formation is also a remnant of sedimentary rocks and is the oldest carbonate rock in New Jersey. It is a white crystalline limestone and marble containing some graphite and sandy layers. At great depth the Franklin Formation was intruded and metamorphosed by molten igneous rock. Exposure today on the surface is due to erosion of thousands of feet of overlying rock during millions of years. The present extent of the gneisses and the Franklin Formation is only a fraction of the original area covered by these rocks.

At Franklin and Ogdensburg the formation contains large beds of a unique zinc ore and some iron ore. A great variety of minerals including diopside, phlogopite, quartz and flakes of graphite are associated with this formation. The graphite may be an evidence of life in the Precambrian Era. Graphite is composed entirely of carbon and is believed to be a remnant of the hydrocarbons of living organisms.

Paleozoic Era

Paleozoic time began with a slow depression of parts of the continent and the invasion of a shallow sea over the surface from a southwesterly direction. Sediments gradually began to accumulate in an elongate depositional basin which extended from Newfoundland through New England, New York, northwestern New Jersey, across eastern and central Pennsylvania, western Virginia and the central Carolinas into Alabama. Source areas for the

sediments were land masses to the east and southeast. The Paleozoic Era lasted approximately 320 million years and the interior sea during this time varied greatly in size, shape and position.

In New Jersey, Paleozoic sediments were deposited during the Cambrian, Ordovician, Silurian and Devonian periods. Rocks from the last three periods of the era, the Mississippian, Pennsylvanian and Permian are not present in New Jersey, but are found in Pennsylvania to the northwest and west.

Cambrian Period - At the beginning of Cambrian time, the eroded Precambrian surface was covered with rock debris. As the sea slowly advanced, the debris was gradually washed, rounded and sorted. During sorting the finer material was laid down in the calm deeper water while the coarser material was deposited nearer shore where the currents were stronger. The sands and gravels which accumulated during this time constitute the Hardyston Quartzite. As the name implies, this formation is normally a quartzite with some conglomerate near the base. The conglomerate contains pebbles of quartz, feldspar, gneiss and shale.

Cambro-Ordovician Time - During the latter part of the Cambrian and the beginning of the Ordovician time, a warm shallow sea covered northern New Jersey. The remains of lime organisms reacting in the sea water produced a calcium carbonate precipitate which consolidated into the Kittatinny Formation. The formation is a dolomitic limestone with some layers of quartz sandstone.

Ordovician Period - Following uplift and a long erosion interval, the Jacksonburg Limestone was deposited on top of Kittatinny sediments in a warm sea which once again invaded the area. The sea contained abundant life, and large quantities of organic remains were deposited on the bottom. This material formed the dark colored, fossiliferous Jacksonburg Limestone.

After the Jacksonburg was deposited, the region was gradually uplifted and the seas retreated from New Jersey and eastern Pennsylvania. During this period of uplift, the exposed land was slowly worn down by erosion.

The sea then readvanced and the streams flowing into the sea carried large amounts of fine silt, mud and fine sand creating a series of sandstones, shales and slates called the Martinsburg Formation.

It is likely that life existed for 100 million years before the Paleozoic Era, but pre-Paleozoic rocks have preserved little or no evidence of life. In New Jersey, the first fossil evidence is worm tubes found in the Hardyston Quartzite. Although the New Jersey Cambrian fossil record is scant, over 500 species of invertebrate animals have been found in other North American rocks. The meager New Jersey record was caused by the prevailing type of deposition. Generally, the seas were shallow, very warm, and rather stagnant, producing an environment where animals could not flourish. Only a few fossils are found in the Kittatinny Formation. Two of the more common are primitive types of algae and the scaphopod, Hyolithellus micans. When the Jacksonburg limestone was deposited, the environment had become very favorable for the existence of life. The limestone, therefore, contains abundant fossil brachiopods, crinoid stems, condonts and bryozoa.

The types of fossils found in the Martinsburg Formation, combined with their relatively rare occurrence, indicate that this deposition was not favorable for abundant life. Graptolites, jellyfish-like animals with individuals living along hanging branches, are found in the Formation. These animals lived in an open sea and are best preserved in a muddy bottom.

At the conclusion of Ordovician time there was an interval of considerable mountain building known as the Taconic Disturbance. In Sussex County

volcanic activity accompanied folding and faulting of the Cambrian and Ordovician formations. Evidence of this activity is found in Rutan Hill, a conical structure near Beemerville which is believed to be an old volcano. The sides of the volcano have been eroded away, leaving the plug or neck. This is the pipelike portion through which lava rose to feed the volcano. Rutan Hill is composed of volcanic breccia and nepheline syenite, a dark, alkaline igneous rock.

Silurian Period - Prior to Silurian time, the earth's surface was greatly modified by the Taconic Disturbance. Many feet of rock were eroded away and the land was low in elevation. Northern New Jersey was slowly covered by an encroaching sea whose shore line was variable. White quartz and slate pebbles were deposited by streams leading to the sea. This material was later cemented by silica into the Shawangunk conglomerate and quartzite. The crest of Kittatinny Mountain is formed by this hard, resistant rock.

After Shawangunk deposition, there was a gradual emergence followed by a later submergence and invasion of a shallow marine sea. At this time the High Falls Formation was deposited. The High Falls is a red, green and olive colored sandstone and shale with some beds of conglomerate. The colors came about by iron rich sediments being washed in and being either oxidized, causing the red, or reduced, causing the green and olive color.

As conditions changed in the shallow marine sea, the Poxono Island, a shale with limy layers, the Bossardville, a fine grained banded limestone, and the Decker Ferry, a limestone and limy sandstone, were deposited. The difference in composition of these formations was dependent on the changing environments which caused different material to be deposited. The absence of marine fossils indicates that non-marine conditions prevailed, forming an earthy shale and

limestone, the Rondout Formation. Following deposition of the Rondout Formation, marine conditions returned, and a thinly bedded dark limestone, the Manlius Formation, was deposited.

Life during Silurian time was still dominated by marine invertebrates such as brachiopods, ostracods, crinoids and corals. During this time some of these animals began to decline in number of varieties and others became more important. The Eurypterids, scorpion-like animals up to 16 feet in length, were the largest animals of this period. Their remains have been found in the Shawangunk conglomerate and quartzite. One of the most common fossils of the time, the ostracod, is preserved in the High Falls Formation. The presence of these creatures indicates that the depositional environment was a very muddy sea bottom. The other marine formations, the Poxono Island, the Bossardville and the Decker Ferry contain varied animal and plant life. The most common fossils are corals, brachiopods, bryozoa and crinoids.

Devonian Period - At the beginning of the Devonian, northwestern New Jersey was covered by a warm narrow marine sea in which a series of limestones, shales and sandstones were deposited. The Devonian seas swarmed with animals of many kinds; brachiopods reached their greatest numbers, pelecypods (clams) became more common, and corals were abundant. Bryozoa and crinoids lived on the coral reefs.

Devonian Formations and Rock Types

(Approx. thickness)

Marcellus Shale - fissile black shale	(Traces)
Onondaga Limestone - hard cherty limestone	(? feet)
Esopus Grit - black gritty limestone	(375 feet)
Oriskany Formation - siliceous limestone	(170 feet)

Port Ewen Shale - shale	(80 feet)
Becraft Limestone - hard, gray, cherty limestone	(20 feet)
New Scotland Formation - hard cherty limestone	(160 feet)
Stormville Sandstone - sandstone	(0-10 feet)
Coeymans Limestone - coarsely crystalline limestone	(40 feet)

From the end of the Devonian Period through the Mississippian, Pennsylvanian, Permian, Triassic, Jurassic and Cretaceous Periods, there was a continuing period of erosion in northern New Jersey. No rocks from these periods are found in Sussex County so that it is impossible to decipher the specific events in the local geologic history.

Cenozoic Era

Tertiary Period - The Tertiary Period was marked in northern New Jersey by the erosion of peneplains. Peneplains are relatively flat surfaces formed by erosion over a wide area. In Sussex County, the most obvious peneplain is the Schooley peneplain, the remnants of which can be seen in the almost even crests of the Pocono Mountains of Pennsylvania, the Kittatinny Mountains and the Highlands. Gentle upwarp and subsequent sculpturing of the different rocks by stream erosion have formed the topography as it appears today. Over many thousands of years this wearing down process carved out the weaker rocks to form the valleys, and left the more resistant rocks as ridges.

During development of the peneplains, the streams in the area were flowing at much higher levels than they are today. One stream, flowing through what is now Culvers Gap, eroded the rocks forming a notch which is called a gap. After many years the stream's headwaters changed, leaving what is now called a wind gap.

Quaternary Period

Pleistocene Epoch - The Pleistocene Epoch, commonly known as The Ice Age, was a time when glaciers covered a much greater area than they do today. Ice Ages or glacial stages alternated with warmer interglacial stages when the ice sheets receded temporarily.

In Sussex County the glacial deposits are believed to belong to three glacial stages, Kansan (oldest), Illinoian, and Wisconsin (youngest). Each stage was named after a state in which the deposits, called drift, are well represented. In New Jersey, the evidence left from the Kansan stage is very patchy. Scattered rocks and clayey till (tough, stoney clay) are found in the uplands, usually the Highlands. The Illinoian stage has left more drift than the Kansan, but the evidence is still scattered. The material is composed of leached and oxidized pebbles and boulders. The appearance of the material is a result of the long exposure to weathering and erosion. This drift is found on hilltops and in low terraces along streams.

The Wisconsin ice sheet was the most recent, and therefore has left the most evidence. The major moraine, a heterogeneous deposit of clay, sand and stone dumped at the front of the glacier in Sussex County, can be traced from Ogdensburg through Lafayette, Halsey and Balesville to Culvers Lake.

The unstratified drift or till deposited by the ice consists of clayey material with intermingled sand, gravel, rock fragments and boulders. Only a small percentage of this till has been transported any distance. Most of the recognizable material is of the same composition as the underlying rock.

The stratified drift, material reworked by running water, is composed of beds of clay, sand and gravel. This material was sorted by melt waters from

the glaciers. Distinct layers can be found with larger rock fragments on the bottom gradually grading to the smallest particles at the top.

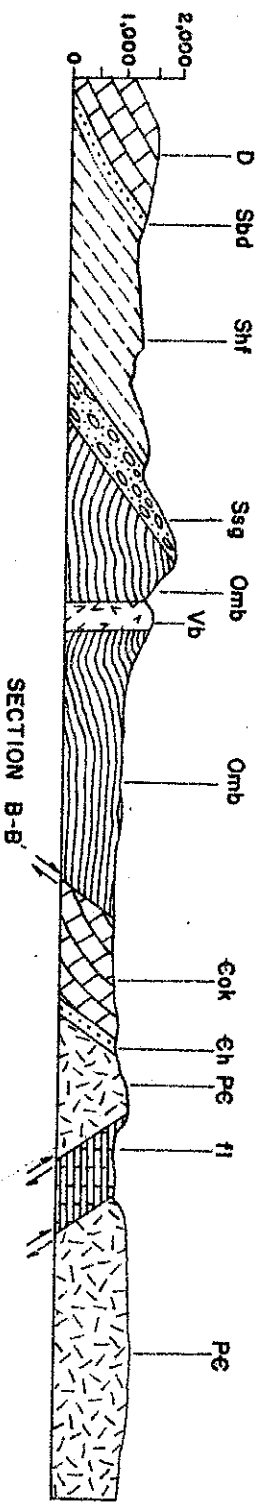
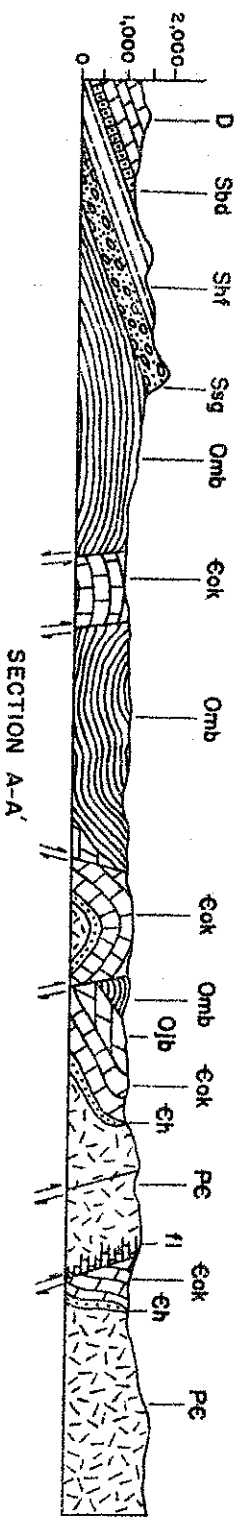
One of the easily recognized characteristics of a recently glaciated region are lakes and ponds. The large number of lakes and ponds which are found in Sussex County were formed by the Wisconsin glacier in one of the following ways.

1. Rock basins produced by glacial erosion (Lake Marcia and Lake Wildwood, east of Hamburg).
2. Basins produced by the damming of river valleys by drift (Catfish Pond and Culvers Lake).
3. Depressions in drift surface (Lake Grinell and Stickle Pond).
4. Basins produced by a combination of reasons (Stag Pond and Losee Pond).

Striations are another feature left by the glaciers. They are formed when rocks caught in the bottom of a glacier are carried over the stationary rock of the region. The resultant scraping causes distinct scratches or polishing marks to appear on bedrock exposures or boulders.

GEOLOGIC CROSS-SECTIONS OF SUSSEX COUNTY

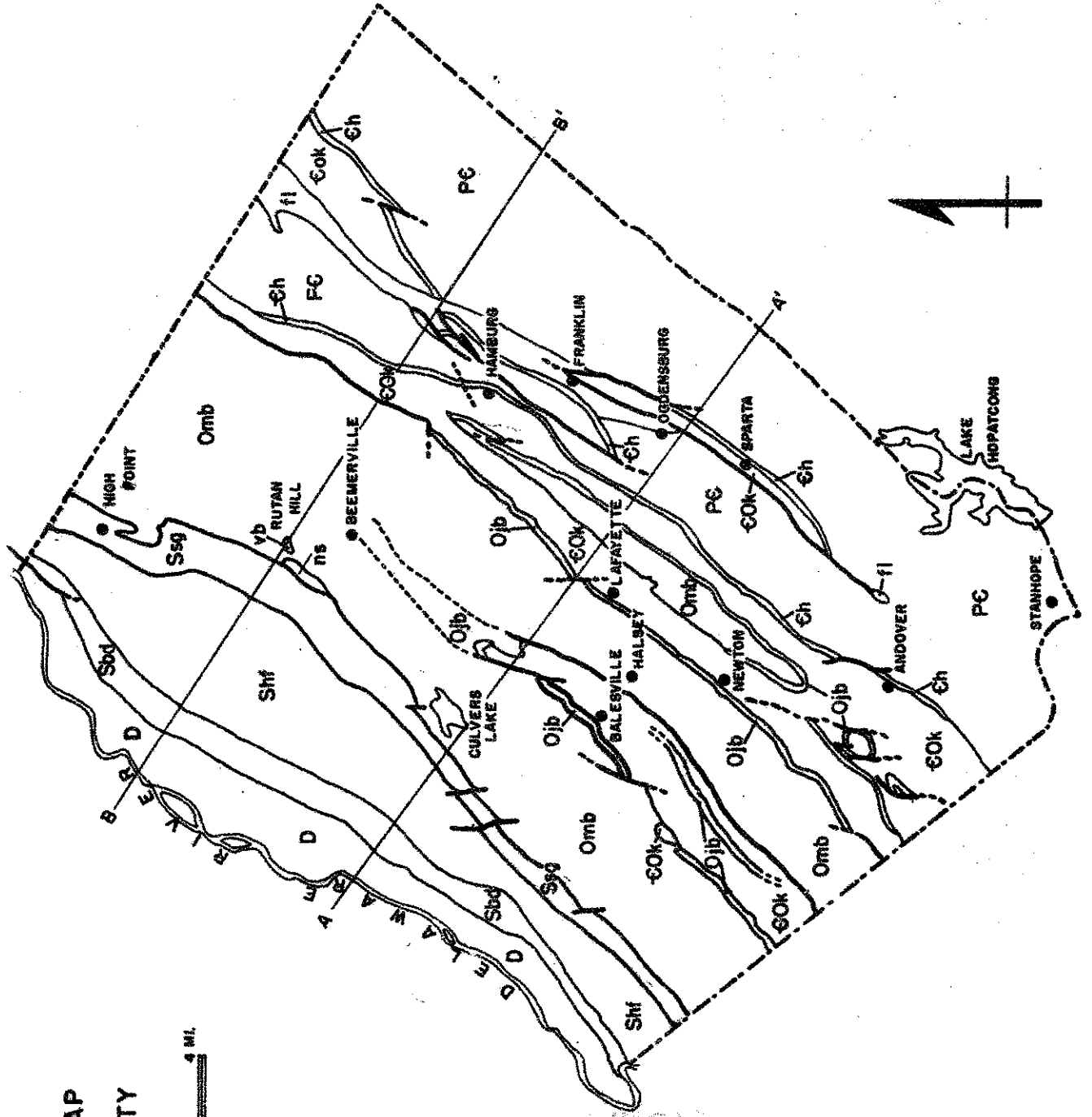
New Jersey Geological Survey 1967
Horizontal Scale: $1\frac{1}{2}$ " = 2 $\frac{1}{2}$ Miles
Vertical $\frac{1}{8}$ " = 500 Feet



LEGEND

- D Devonian limestone, shale & sandstone
- Sbd Silurian limestone & shale formations
- Shf High Falls Formation
- Ssg Shawangunk Conglomerate
- Omb Martinsburg Formation
- Ojb Jacksonburg Formation
- Eok Kittatinny Formation
- Eh Hardyston Quartzite
- Vb Volcanic Breccia
- Fi Franklin Formation
- Pc Precambrian (undifferentiated)

**GEOLOGIC MAP
OF
SUSSEX COUNTY
SCALE**



LEGEND

- D Devonian limestone, shale & sandstone
- Sbd Silurian limestone & shale formations
- Shf High Falls Formation
- Ssg Shawangunk Conglomerate
- Omb Martinsburg Formation
- Ojb Jacksonburg Formation
- COK Kittatinny Formation
- Ch Hardyston Quartzite
- ns Nepheline Syenite
- vb Volcanic Breccia
- fl Franklin Formation
- PC Precambrian (undifferentiated)

Fault----- Contact-----

BOUNDARIES

State----- County-----

A----- CROSS SECTION----- A'

BASE MAP ATLAS SHEET #40

MINERAL PRODUCTION AND HISTORY

When New Jersey is mentioned many geologists think first of the ore deposits in the Franklin-Sterling Hill area. The ore body found here is unlike any other known deposit in the world. There are three main ores in the deposits; Franklinite, Willemite and Zincite. Its principal metals are zinc, manganese and iron. Franklinite contains all three metals as a complex oxide. The other two ores, Willemite, a silicate, and Zincite, an oxide, both contain zinc. The unusual composition of deposits in the Franklin-Sterling area, concealing from early prospectors and mining experts for many years the nature of the property, made necessary the development of new milling and smelting methods to extract the metals.

Perhaps the earliest discoverers of the deposit were Dutch prospectors and miners in 1640. No doubt they were baffled by what they found for the area was abandoned.

One of the first men associated with the deposits was William Alexander, the Earl of Stirling, who inherited the property which now includes the Sterling Hill (Ogdensburg) mine. Lord Stirling tried to develop the neglected mineral resources of the estate. Although he was not successful with the zinc, he produced iron for the Colonies.

Elias Ogden, a son of a prosperous neighbor of Stirling's, later purchased the Sterling Hill mine. In the early nineteenth century Elias Ogden's brother-in-law, Dr. Samuel Fowler, acquired properties which included both the Sterling Hill and Franklin deposits. He failed in his efforts to mine the ore but his son, Colonel Samuel Fowler, profiting from his father's mistakes, did not attempt to work the mines without technical assistance. Instead, he made strenuous efforts

to organize a group of experts to work out the puzzling deposits. This group of men in 1848 formed the Sussex Zinc and Copper Mining and Manufacturing Company, the forerunner of the present concern, The New Jersey Zinc Company.

There is only one mine in operation today, the underground workings of the Sterling Hill (Ogdensburg) mine. The ore has increased in value and production annually since 1961 when the mine was reopened after several years of inactivity.

In all, forty-two minerals were found first at Franklin and Sterling Hill. At Franklin the old mine dumps are open to mineral collectors at a minimal charge.

Limestone, another mineral commodity of Sussex County, is quarried near Newton and Franklin. The limestone is burned and hydrated lime is produced for construction, agricultural and chemical applications.

Glacial sand and gravel is quarried near Andover and Sparta. The majority of this material is used for construction purposes.

Reed-sedge peat produced near Newton and Stanhope is used primarily as a soil conditioner. Organic matter gradually accumulated on the Pleistocene Lake bottoms and underwent slow and partial decomposition under the water. This residual organic material formed peat.

GEOLOGIC TIME SCALE

Geologic time intervals are unequal subdivisions of the earth's history corresponding to definite geologic events. Eras are the largest divisions of time and contain many periods, which are further subdivided into epochs. Formations, mappable rock units, are placed within the period during which they were formed. A formation's place within the stratigraphic column is determined by the predominant forms of life preserved within the rocks; distinctive lithology, and 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 local or regional modifications are sometimes used for greater clarity.

GEOLOGIC TIME SCALE

Era	Period	Formation or Rock (approx. thickness)	Approx. no. of million years
CENOZOIC	Recent Quaternary Pleistocene	Soil and Alluvium	0-1
		Glacial Drift (0-460 ft.)	
MESOZOIC	Tertiary	Not present in county	1-60
	Cretaceous	Not present in county	60-130
	Jurassic	Not present in state	130-155
	Triassic	Not present in county	155-185
	Permian	Not present in state	185-210
	Penn. Carboniferous Miss.	Not present in state	210-265
PALEOZOIC	Devonian	Marcellus shale (Traces)	265-320
		Onondaga Limestone (200? feet)	
		Esopus Grit (375 feet)	
		Oriskany Formation (170 feet)	
		Port Ewen Shale (80 feet)	
Silurian	Manlius Formation (35 ft.)	320-360	
	Rondout Formation (39 ft.)		
	Decker Ferry Limestone (52 ft.)		
	Bossardville Ls. (12-100 ft.)		
	Poxono Island Shale (? ft.)		
Ordovician	High Falls Formation (2,300 ft.)	360-440	
	Shawangunk Conglomerate (1,500 ft.)		
Cambro- Ordovician	Volcanic Breccia	360-440	
	Nepheline syenite		
Cambrian	Martinsburg Fm. (3,000 ft)	440-520	
	Jacksonburg Fm. (125-300 ft.)		
PROTEROZOIC	Precambrian	Kittatinny Fm. (2,500-3,000 ft)	520-2,100
		Hardyston Quartzite (5-200 ft.)	
		Franklin Formation and assorted gneiss (? ft.)	

Dashed lines indicate formation being deposited in two time periods.

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