

A Brief Geologic History of the Hudson Valley

Middle Proterozoic Eon (1,300 – 800 Ma)

Proto-North America, called Laurentia, was much smaller than the present-day continent and located deep in the Southern Hemisphere. The continental crust which today underlies New York State did not exist prior to this time. The area was a shallow sea where sands, clays, and occasional volcanic ash falls were accumulating and life on Earth was still single-celled.

During this time, Laurentia collided with another block of continental crust called Amazonia (today comprising part of the South American continent). This collision resulted in a tremendous mountain-building event called the Grenville Orogeny helped to form a supercontinent called Rodinia. A modern-day analogue to this collision is India's collision with Asia over the past few tens of millions of years to form the Himalaya. The Grenville Mountains were the size of the modern Himalaya and this collision resulted in high-grade, highly-deformed metamorphic rocks, late-stage shear zones, and igneous intrusions.

These rocks form the basement of New York State (and the entire eastern seaboard of modern-day North America) and are exposed in the Adirondacks and Hudson Highlands. In the Hudson Highlands region, late-stage fluid flow resulted in numerous veins of historically-significant magnetite (Fe_3O_4) iron ore deposits. A classic example of Grenville-age metamorphic rock is the Storm King Granitic Gneiss exposed at the top of Bear Mountain in the Hudson Highlands. Another example is the Fordham Gneiss exposed in Van Cortlandt Park of the Bronx.

Late Proterozoic Eon (800-543 Ma)

While the Grenville Mountains were slowly eroding away, the supercontinent of Rodinia began rifting apart. Prior to the assembly of Rodinia, the coastline of Laurentia was near present-day Ohio, after the rifting of Rodinia it was in present-day New York. In other words, the Grenville Orogeny increased the size of Laurentia by adding continental crust (called the Grenville Province) which underlies all of modern New York. This rifting resulted in the formation of a passive margin continental shelf in the area of the modern-day Hudson Valley.

Cambrian Period (543 – 490 Ma)

Rodinia has now fully rifted apart. Laurentia is still in the Southern Hemisphere but now in a subtropical climate zone. The Hudson Valley region is a passive margin continental shelf on the coast of Laurentia accumulating sands, clays, and carbonate muds which will form the sedimentary rocks sandstone, shale, and limestone. Marine invertebrates are now abundant in the world's oceans and fossils are commonly preserved in these Paleozoic Era marine rocks.

Ordovician Period (490 – 443 Ma)

The Ordovician saw the approach of a chain of volcanic islands. These islands, called a volcanic island arc, were formed by the subduction of oceanic crust off the coast of Laurentia. A modern analogue are the Aleutian Islands off Alaska where the Pacific seafloor is subducting beneath the Bering Sea. As oceanic crust sinks into the seafloor trench, it melts at depth providing magma for a chain of volcanic islands (and producing large earthquakes as it forces its way down).

Between the volcanic island arc and the coast of Laurentia, a narrow, deep marine basin formed which accumulated mud in an anoxic environment. These later formed black shales. Interbedded with the shales are volcanic ash layers and thick sandstone beds from submarine turbidity current landslides.

Toward the latter part of the Ordovician Period, this volcanic island arc collided with Laurentia resulting in the Taconic Orogeny. This mountain building event severely folded and thrust faulted the black marine shales which can now be seen adjacent to the Hudson River north of the Hudson Highlands up through Albany (these Ordovician rocks go by numerous names including the Martinsburg, Snake Hill, Austin Glen, and Normanskill Formations).

South of the Hudson Highlands, the Cambro-Ordovician sediments were metamorphosed by the Taconic Orogeny to form the New York City Series of rocks (also called the Manhattan Prong). Limestones were metamorphosed into the Inwood Marble (well exposed in Ingham Park in Manhattan) while clastic sediments like sandstones and shales were metamorphosed into the Manhattan Schist (well exposed in Central Park).

Silurian Period (443 – 417 Ma)

During most of the Silurian Period, eastern New York was above sea level due to Taconic mountain building. As the Taconic Mountains eroded away, sediments were washed to the west via braided, sediment-loaded stream channels and floodplains. The landscape was much different than today's since there was very little terrestrial life at this time. These quartz-rich fluvial sediments are preserved in the Hudson Valley as the Shawangunk Conglomerate. One of the best places to study this rock unit is at Lake Minnewaska State Park.

Toward the end of the Silurian Period, tidal mudflat and shallow marine deposits appear as the Rondout Formation. This is the beginning of a new marine incursion into the area of the Helderberg Sea. The Rondout Formation is famous for its use as a natural hydraulic cement which was used in building much of New York City in the late 19th and early 20th centuries. The Rondout Formation and numerous abandoned cement mines can be seen in the vicinity of Rosendale in Ulster County.

Devonian Period (417 – 354 Ma)

The early Devonian saw the growth of the Helderberg Sea and the deposition of shallow marine limestones. These limestones can be seen throughout the Hudson Valley between the Highlands and Albany lying unconformably on top of the Ordovician shales and are rich in marine invertebrate fossils. These limestones can be seen throughout the Hudson Valley.

During the Devonian Period, a small continental land mass called Avalonia was approaching Laurentia. The collision of this land mass caused yet another mountain-building event, the Acadian Orogeny. This collision folded and faulted the early Devonian limestone which had formed in the Helderberg Sea. These can be seen along Route 23 west of Catskill in Greene County. The Himalayan-scale Acadian Mountains eroded to produce a massive wedge of Late Devonian sediments called the Catskill Delta. Fossil evidence shows that the rivers and floodplains of the Catskill Delta supported a forests of plants along with insects and amphibians. Life had conquered the land and vertebrate fish had developed in the adjacent seas.

Carboniferous Period (354 – 290 Ma)

Virtually no Carboniferous age rocks are preserved in New York. They are abundant in adjacent Pennsylvania and associated with massive coal deposits. During this time, New York was a high area subject to erosion rather than deposition.

The most significant event of the Late Carboniferous (Pennsylvanian) Period was the Alleghanian Orogeny. This final mountain-building event resulted from the collision of African with Laurentia to form the supercontinent of Pangaea and also resulted in extensive folding and thrust faulting of rocks in southeastern New York.

Permian Period (290 – 248 Ma)

No Permian-age rocks are preserved in New York. It was now a mountainous area eroding sediments further to the west.

Triassic Period (248 – 206 Ma)

Pangaea began to rift apart during the Triassic forming rift valleys up and down what is now the east coast of North America. A modern analogue is the East African Rift. Coarse terrestrial sediments washed into this rift, stained red from oxidized iron they're called redbeds, and freshwater lakes formed in some areas. Volcanic activity was common as a result of the crustal thinning. In southeastern New York, Triassic-age redbeds of the Newark Rift are easily seen along the Thruway between Suffern and the Tappan Zee bridge.

The Mesozoic Era was the time of the dinosaurs but the only evidence of dinosaurs in New York are from a single set of tracks found in the Triassic sediments of Rockland County. These tracks represent the small, bipedal, theropod *Coelophysis*.

Jurassic Period (206 – 144 Ma)

As rifting continued, magma intruded the Newark Rift resulting in surface lava flows and the subsurface Palisades Sill exposed along the west bank of the Hudson north of the George Washington Bridge.

Cretaceous Period (144 – 65 Ma)

New York has no rocks from this time although marine sediments of this age are found on the New Jersey coastal plain.

Tertiary Period (65 – 1.8 Ma)

Rocks of this age are similarly lacking in New York State.

Pleistocene Period (1.8 Ma – 10 ka)

The Pleistocene is the time of the great ice age. There were actually at least four major advances and retreats of glacial ice affecting New York during this time. The present-day landscape of the Hudson Valley has been greatly affected by this glaciation by both erosion from the advancing glaciers and deposition of sediments as the glaciers melted away.

Quaternary Period (10 ka – Present)

The most geologically-significant event of the Quaternary in the Hudson Valley was the existence of large post-glacial lakes after the Pleistocene deglaciation. These lakes formed clay deposits along the Hudson which were extensively mined by the brickmaking industry with the river providing easy transport to New York City.