





Kittatinny Ridge runs approximately 40 miles through the county, hugging its western margin. The ridge has elevations generally between 1,200 and 1,500 feet above sea level, and an average width of five miles. At High Point, which is the northernmost extent of the Kittatinny Ridge in Sussex County, the elevation tops out at 1,803 feet, the highest point in New Jersey.

The lowest points in Sussex County are along the Delaware River at the mouth of the Flat Brook (300 feet), and along the Wallkill River at the New York State line (380 feet). The Kittatinny Valley, located between the Highlands and the Kittatinny Ridge, has elevations generally between 600 and 700 feet. It is in this area that the county's agricultural economy is primarily based.

## Geology

### The Highlands

The Highlands is part of the larger New England Upland, which includes the Green Mountains of Vermont and the Berkshires of western Massachusetts. The Highlands cuts across parts of Hunterdon, Warren, Sussex, Somerset, Morris, Passaic and Bergen Counties, and is comprised of northeast-trending ridges that rise generally 300 to 500 feet above the parallel river valleys.

## Bedrock Geology

Highlands bedrock is comprised predominantly of granite, gneiss and, to a lesser extent, marble (See **Map 2: Geology in Sussex County**). The rocks date to the Precambrian, and are the oldest in New Jersey. They formed between 1.3 billion and 750 million years ago. These igneous rocks were formed through the intense heat, compression and deformation of the preexisting rock. This process was the earliest event in the formation of the Appalachian Mountains.

Within the general assemblage of Precambrian rock, there are several northeast-running belts of Paleozoic rocks, including sandstone, shale and limestone. The origin of these sedimentary rocks, which are much younger than the surrounding rock, can be traced to a series of gravel, sand and silt outwashes from nearby mountains, as well as from the calcareous sediments of marine animals deposited in inland seas created when the continent broke apart. These depositions occurred between 550 million and 350 million years ago, and completely covered the older Precambrian rock.

Three mountain-building episodes, occurring about 1,000, 450, and 300 million years ago, shaped the current Highlands bedrock geology. Intense pressure folded the Highlands region and thrust the area westward on a series of faults. The first episode lifted the landscape to elevations near those of the present-day Rocky Mountains. This action also trapped the sedimentary Paleozoic rocks between faulted blocks of Precambrian rock. This assemblage of northeast-southwest running belts of Paleozoic rock within the larger Precambrian rock is the modern structure of the Highlands.

## Surficial Geology

Erosion of the Highlands province began in earnest in the Mesozoic, around 190 million years ago. However, it was not until 10 million years ago, in the Miocene, that the Highlands' current form began to take shape.

Originally, drainage patterns in the Highlands were to the southeast, but from 10 million years ago until 2 million years ago, the pattern shifted gradually to the southwest, as streams and other forces eroded channels in the belts of weak sedimentary rocks. Once streams were entrenched in the southwest-trending valleys, stream erosion continued to deepen the valleys. The Precambrian rock, being more resistant to erosion, eventually formed the ridges.

Rivers, such as the Musconetcong and the South Branch of the Raritan River and the Black River outside of Sussex County but within the Highlands region, exemplify this southwest pattern through broad river valleys. The Wallkill River and its valley also conform to this pattern, although it flows northeast rather than southwest.

## **Ridge and Valley**

The Ridge and Valley physiographic province occupies a small portion of New Jersey.

The eastern boundary of the Ridge and Valley extends northeasterly from the Delaware River north of Phillipsburg, to the New York State line approximately where the Wallkill River enters New York State.

The Ridge and Valley province, so named for its topographic features of long parallel ridges and wide fertile valleys, extends southwestward into Pennsylvania where the Kittatinny Ridge continues nearly to Harrisburg. The Kittatinny Ridge becomes Blue Mountain in Pennsylvania, and the Blue Ridge further south in Maryland and Virginia.

The Ridge and Valley province also extends northeastward into New York State, where the Kittatinny Ridge becomes Shawangunk Mountain. The Ridge and Valley province in total extends from northeastern Alabama through Virginia, Pennsylvania, New Jersey, and north through the Hudson, Champlain and Saint Lawrence Valleys.

### *Bedrock Geology*

The land of New Jersey was originally part of a larger continent that broke up in Precambrian and Mesozoic time. As this occurred, ocean water infiltrated the rifts, depositing sand, silt and carbonate sediments. Because of this, the underlying rock of the Ridge and Valley is sedimentary. It consists primarily of sandstone, shale and limestone deposited between 550 and 350 million years ago (see **Map 2**).

The rocks were flat-lying, until pressure from the southeast compressed them in a series of folds during the three major episodes of mountain-building. The most recent episode took place roughly 300 million years ago. Volcanic activity accompanied mountain building in Sussex County. Evidence of this activity can be found southwest of Colesville in Wantage Township, where the neck of an old volcano remains. The neck is the part of the volcano through which lava rises to the surface. Once the mountains were formed, erosion, weathering and glaciation shaped the landscape today.

### Surficial Geology

As with the Highlands, the different rocks that comprise the Ridge and Valley have various degrees of resistance to weathering. The most resistant is conglomerate and sandstone, which not coincidentally underlies the Kittatinny Ridge and Walpack Ridge. The weaker rocks are shale and limestone, and these underlie the upper Delaware Valley and the Kittatinny Valley.

Within the Kittatinny Valley, there are two different elevation levels that correspond to the underlying material. Those parts of the Valley that are underlain by shale are several hundred feet higher than those underlain by limestone. Limestone areas in the Kittatinny Valley are the most erosion-prone rocks in the county. Because of their susceptibility to erosion, and their slight solubility in water, limestone areas in Sussex harbor great biological diversity and contain significant natural value. The Kittatinny Valley Limestone areas are among the most productive bedrock aquifers in the county.

## **Water and Wind Gaps**

For its entire 35-mile length in New Jersey, the Kittatinny Ridge is remarkably consistent. It is substantially broken only once over that length, at Culvers Gap. The other major gap in New Jersey is the Delaware Water Gap, located in Warren County at the New Jersey-Pennsylvania border. The Delaware Water Gap, which is a textbook example of a water gap, was formed when the Kittatinny Ridge rose around the preexisting river. The river's power to cut through the emerging mountain was greater than the mountain's rise, and the Delaware maintained its course through the ridge.

Culvers Gap was formed the same way as the Delaware Water Gap, most likely by a branch of the Paulins Kill cutting through the emerging Kittatinny Ridge. Over time the stream flowing through the gap was diverted, or captured, by the Flat Brook system, which flows on the west side of the Kittatinny Ridge and was eroding its headwall more quickly than the stream flowing through Culvers Gap. This had the effect of redirecting the stream into the Flat Brook, thus leaving Culvers Gap dry. Scenarios like this are quite common throughout the Appalachian Mountains. Wind gaps are formed wherever larger rivers erode their basins more quickly and capture the streamflow of smaller waterways by literally breaking through to a different drainage basin.

## **Glaciation**

In addition to stream erosion, glaciers have given shape to the current landscape. Over the past 1.5 million years three distinct periods of glaciation have occurred in northern New Jersey, all of which have covered Sussex County's entire land area. The first two glacial episodes, called the pre-Illinoian and Illinoian, occurred more than 800,000 years ago and about 150,000 years ago, respectively. Little is known about these periods.

The most recent glaciation was the Wisconsinan, occurring about 20,000 years ago. This episode has left the most profound mark on the Highlands and Ridge and Valley landscape. Ice in the Wisconsinan glacier is believed to have been almost 3,000 feet thick. The glacier flowed over northern New Jersey, scouring away pre-glacial soil from Wawayanda and Hamburg Mountains and the Kittatinny Ridge, exposing bedrock outcroppings. The Wisconsinan glacier also further defined pre-existing stream valleys by plucking out weaker rocks on the sides of the ridges and broadening the flood plains. Throughout Sussex County many glacial features can be observed, indicating the extent to which glaciers have shaped the present landscape. Besides the craggy ridgetops previously mentioned, glaciers have created many features including drumlins, moraines and glacial lakes. Drumlins are tear-drop shaped mounds of till that indicate the direction in which glaciers flowed over the land. These are found throughout Kittatinny Valley and on Kittatinny Mountain in areas of thick till.

Moraines are mounds of till and other debris deposited at the end and sides of glaciers, as well as at points along the glaciers recession. There are two major recessional moraines in Sussex County: the Ogdensburg-Culvers Gap-Dingmans Ferry moraine and the Augusta-Montague moraine. Both of these moraines originate in Kittatinny Valley, cross

Kittatinny Mountain and continue to the Delaware River.

Glacial Lakes were formed when till plugged river drainages. These lakes included Lake Wallkill, Lake Hamburg, Lake North Church and Lake Sparta, in the eastern part of the county, and Lakes Newton, Stillwater and Millbrook in the central and northwestern part. Most glacial lakes are gone; however, two that exist today are Swartswood Lake and Lake Owassa. The lakes are located on the eastern flank of the Kittatinny Ridge, in Stillwater and Frankford Townships, respectively.

A comparison of glaciated and non-glaciated landscapes reveals the extent to which the Wisconsin glacial has shaped the landscape. North of the Wisconsin's terminal moraine, the Highlands landscape is rugged, with thin soils and on ridgetops, steepwalled valleys and numerous bedrock outcroppings and glacial erratics. South of the moraine, the features are much gentler: river valleys are broad, ridgetops remain thickly forested and relief between valley and ridgetop is much less extreme.

The Ridge and Valley province contains similar features. The Kittatinny Ridge has thin, rocky soils, supporting pitch pine and chestnut oak, while the valleys contain glacial sediment and have developed productive agricultural economies based on the land's fertility. **Map 3: Glacial Sediment in Sussex County** depicts glacial remnants throughout the county. These features are an important component of the region's natural history.

