FRENCH CREEK STATE PARK, BERKS AND CHESTER COUNTIES

PIEDMONT ROCKS AND HOPEWELL FURNACE

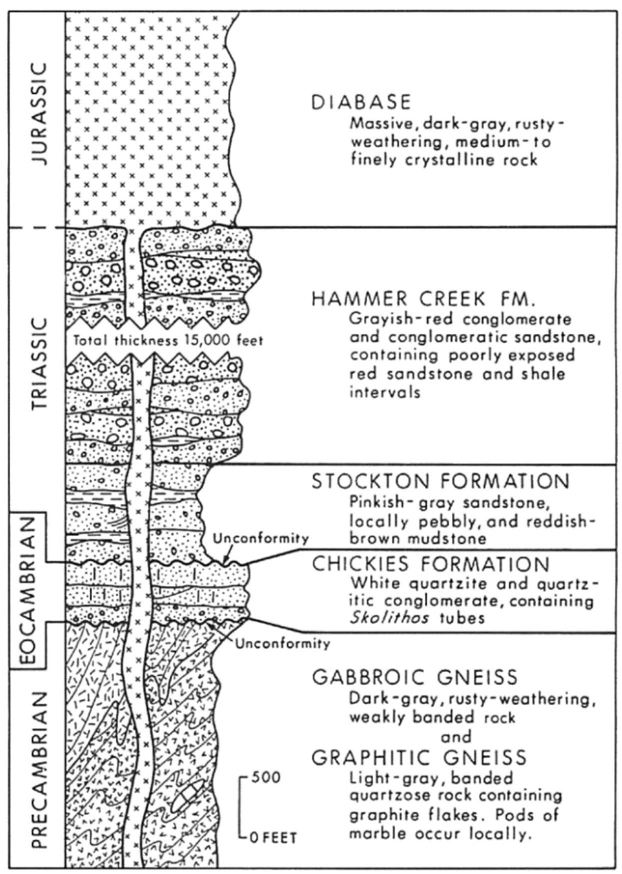
French Creek State Park encompasses nearly 7,500 acres of hilly, forested country in the densely populated Piedmont physiographic province of southeastern Pennsylvania. Because this part of the state was the first to be settled, its mineral resources and natural features have played a part in Pennsylvania's history for more than 300 years. Together with adjacent Hopewell Furnace National Historic Site, French Creek State Park provides excellent opportunities for studying the local geology and its relationship to past and present human activities.

General Geology

Both French Creek State Park and Hopewell Furnace National Historic Site straddle the boundary between the two geologic divisions of the Piedmont. Southeast of Hopewell Lake, metamorphic rocks of the "Crystalline Uplands" form Mount Pleasure and nearby hills; these rocks range in age from about 580 million to 1 billion years old. The rest of the area is underlain by 185- to 200-million-year-old sedimentary and igneous rocks of the "Mesozoic Lowlands."

The geologic column to the right includes a brief geologic description of each of the rock units that crop out in the vicinity of the park. The heavy, wiggly lines indicate **unconformities,** or erosional surfaces that separate rocks of greatly different geologic ages. The upper unconformity is of particular importance in the park area, as it marks the boundary between the intensely folded and highly altered (metamorphosed) rocks of the crystalline Piedmont and the mildly deformed rocks of the Mesozoic Lowlands. Another very significant geologic contact is that between the diabase—the youngest rock in the park area—and all of the older rocks. This is normally an **intrusive contact** formed by the forceful injection of a molten magma (melted rock which later crystallized as diabase) into previously existing rocks.

The geologic map in this park guide shows the distribution of the rock units in the park area. Note that most of French Creek State Park and Hopewell Furnace National Historic Site is underlain by sandstones and conglomerates of the Triassic-age Stockton



Geologic column.

and Hammer Creek Formations. These rocks were originally deposited as sand-and-gravel stream sediments early in the "Age of Dinosaurs," about 200 million years ago. Fossil tracks and trails of these reptilian creatures have been found in similar rocks of the same age at several places near the park, most recently at the Limerick Nuclear Power Station 10 miles to the east. Thus, it is reasonable to assume that when sand and gravel were being deposited in the park area during the Triassic Period, dinosaurs were fording the gravelly streams and walking across the muddy sand banks.

Topography

The highly irregular topography that characterizes French Creek State Park is due to variations in the resistance to erosion of the many rock units composing the landscape in this part of Pennsylvania. Although only a few rock types are actually exposed in the park (see the geologic column), several of these form resistant hills and ridges.

The oldest important unit, the quartzitic Chickies Formation, underlies Mount Pleasure, the loaf-shaped hill in the south-central part of the park (1).

Much younger in geologic age, but equally resistant to erosion, are the coarse conglomerates of the Hammer Creek Formation (F and G). These rocks underlie Williams Hill in the southwestern part of the park and form a range of hills to the north, including Chestnut Hill in the east-central part of the park, Brush Hill in the west-central part of the park, and Long Mountain about 1 mile northwest of the park. Many angular to subrounded fragments of pinkish-gray sandstone and quartz-pebble conglomerate derived from the Hammer Creek Formation can be found in the picnic area on Williams Hill, and the rustic cabin on the picnic grounds is built of this same material.

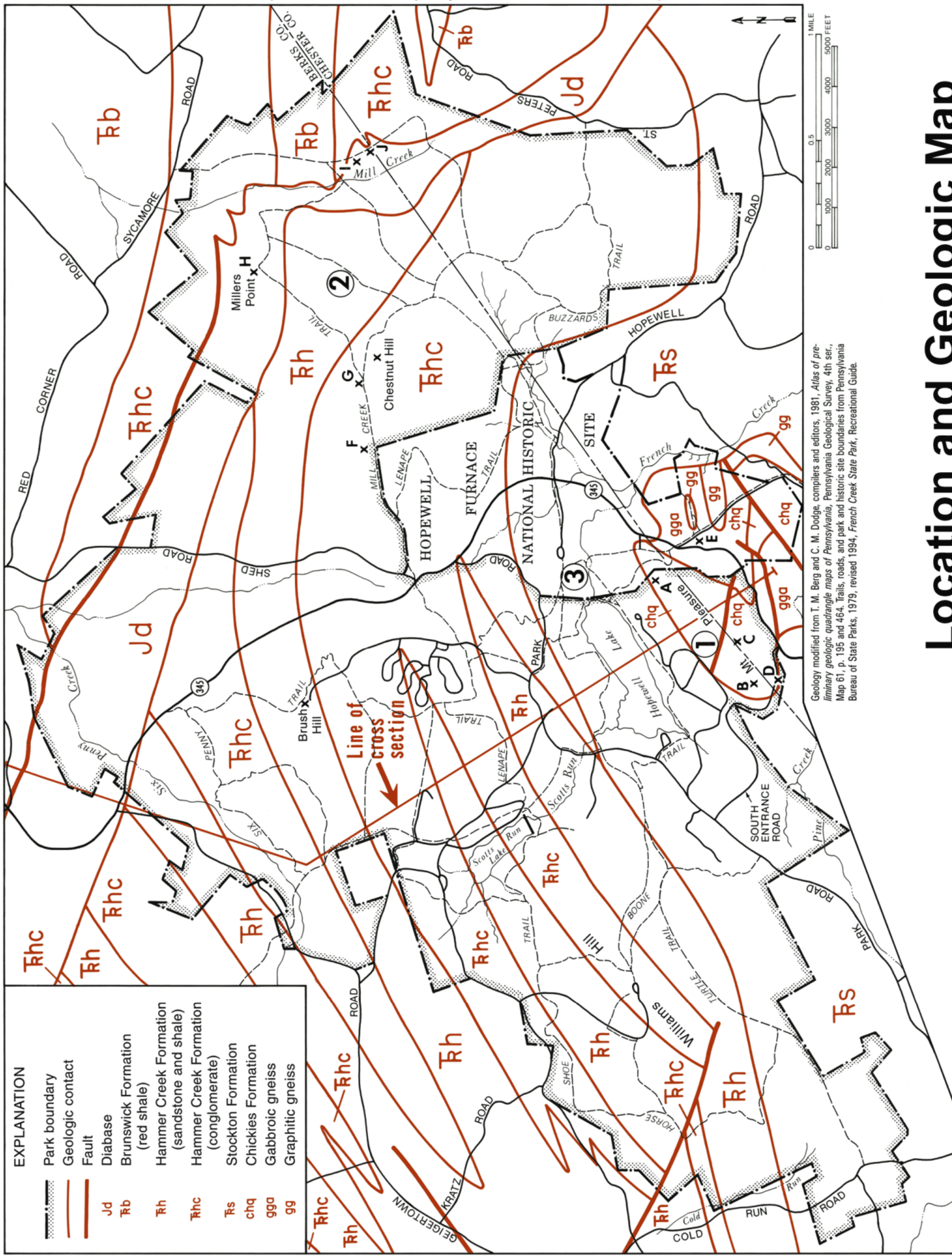
Lastly, the intrusive diabase forms Millers Point in the northeastern part of the park (H). It also underlies Monacacy Hill about 1 mile north of the park and the high knobs north and northwest of Long Mountain. Another diabase ridge occurs at St. Peters, a little more than 1 mile outside the park to the southeast. All of these diabase ridges lie along the outcropping edge of the Morgantown **pluton**. (A pluton—from Pluto, the Greek god of the underworld—is a large body of igneous rock that has crystallized at considerable depth within the earth's crust.) Several thousand feet of overlying rock must have been eroded away to expose this diabase at the present land surface.

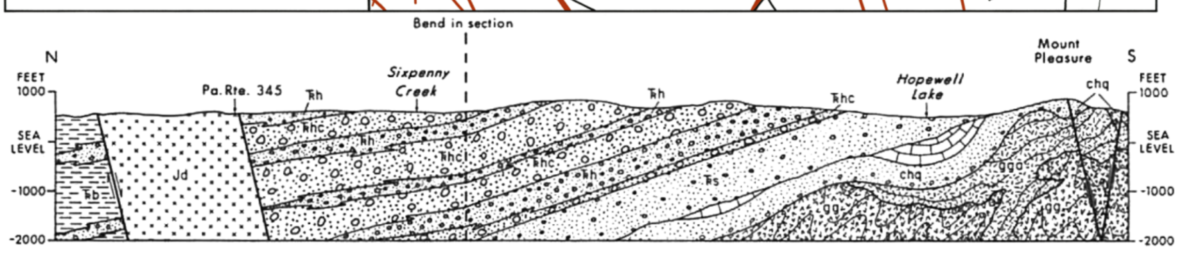
Let us now visit a few areas within the park and adjacent Hopewell Furnace National Historic Site to examine some of the significant geologic and historic features.

(1) Mount Pleasure

Mount Pleasure, an elongate, smoothly contoured, 885-foot-high hill south of Hopewell Lake, is formed of the oldest rocks in the park area (see the location and geologic map and the geologic column). The crest and steep northern and western slopes are underlain mainly by quartzite of the Eocambrian-age Chickies Formation, whereas the eastern slopes are underlain by Precambrian-age gabbroic gneiss. Several **faults** (large fractures along which earth movements have taken place) displace these rocks in a rather haphazard manner. Mount Pleasure is the northernmost part of an area of Eocambrian and Precambrian rocks that is completely separated from similar rocks to the south by the part of the Jurassic-age Morgantown diabase pluton that trends east-west between Elverson and St. Peters. On the east, north, and west, this area of very ancient rock is surrounded by sedimentary sandstones and conglomerates of the Stockton Formation. All of these rock types (except

Location and Geologic Map





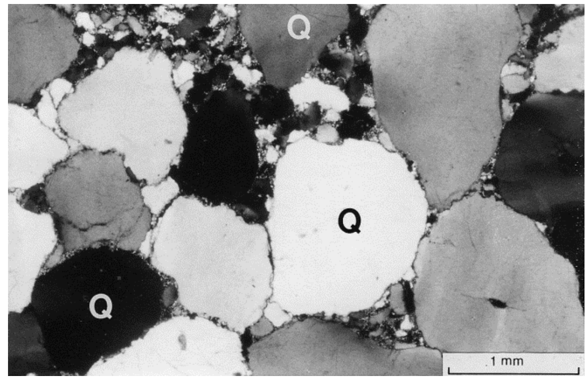
Schematic Geologic Cross Section

the diabase) can be easily seen along the slopes of Mount Pleasure.

At A, approximately 1,700 feet south of Hopewell dam, the hill slope is covered by a great mass of angular, lichen-covered quartzite boulders, many of which are 3 feet or more in diameter. These boulders form a continuous blanket (called **talus**) that extends upslope more than 100 feet to a topographic bench formed by jumbled, intensely fractured outcrops of Chickies quartzite. The boulders originated from the physical weathering of massive quartzite outcrops. Presumably much of this weathering took place during the latter part of the "Ice Age" (about 15,000 years ago), when rock outcroppings, even in this part of Pennsylvania—50 miles south of the limits of continental glaciation, were subjected to intense frost action. The growth of ice crystals within fractures in the rock split the outcropping ledges into discrete boulders that then moved downslope under the influence of gravity. Since most of the trees on the talus slope are relatively straight, it is evident that little downslope movement has taken place recently (at least within the time it took the trees to grow to diameters of up to 6 inches). Actually, significant movement of boulders on this slope probably ceased several thousand years ago when the climate warmed to its present condition.

At B, at the west end of Mount Pleasure, many blocks of light-gray, coarse-grained Chickies

Talus of Chickies quartzite on Mount Pleasure (A).



Microscope photograph of a piece of Chickies quartzite from the west slope of Mount Pleasure (B). (Nearly 100 percent of this rock is composed of the mineral quartz, Q.)

quartzite containing conspicuous sediment-filled tubes 0.1 to 0.2 inch in diameter and up to 12 inches long can be found. These tubes are called *Skolithos*, and they are interpreted as representing the burrows of soft-bodied worms that inhabited the sands of an ancient beach. The beach sand was originally deposited as loose sediment approximately 580 million years ago and was later recrystallized and cemented into quartzite of the Chickies Formation.

In the vicinity of C, numerous quartzite boulders containing conspicuous white **veins** of quartz occur. There are neat, sharp contacts between the veins and the rock, and the banding of the quartz is parallel to these boundaries. These features indicate that the quartz entered the rock in liquid form (probably in a watery solution) and filled existing cracks and fractures. Thus, the cross-cutting quartz veins are *younger* than the quartzite rock they inject. A similar relationship, but on a much larger scale, exists between the diabase and the Hammer Creek conglomerate in the eastern and northern parts of the park (see the geologic cross section).

Exposed along South Entrance Road at D is a striking conglomerate in the Stockton Formation. It is composed of angular to

Coarse conglomerate in the Stockton Formation along entrance road (D).

slightly rounded quartz pebbles and cobbles up to 6 inches or more in diameter. The large rock fragments are surrounded by a matrix of coarse, angular sand grains. If you examine the pebbles and cobbles closely, you will see that they are pieces of Chickies quartzite that have been slightly stained with brownish iron oxide. However, this conglomerate rock was actually formed much later than the Chickies Formation. It is part of a relatively small, fan-shaped deposit that was laid down by streams during the Triassic Period, some 200 million years ago. In those ancient times, Mount Pleasure apparently stood as a topographic prominence much as it does today, but probably considerably higher and steeper. Swiftly flowing streams eroded out weathered pieces of quartzite from the mountainside, transported this coarse, gravelly material downslope, and deposited it as a broad **alluvial fan** where the slopes flattened out at the base of the mountain. This is the coarsest, most angular conglomerate exposed in the park; the pebbles and cobbles are relatively angular because they were transported only a short distance before final deposition.

At E, on the eastern side of Mount Pleasure and in the woods on the east side of Pa. Route 345, many small, rounded boulders of dark-gray, weakly banded gabbroic gneiss occur. These boulders have weathered free of the bedrock ledges concealed under the leaf mold and soil. The gabbroic gneiss is composed largely of the minerals plagioclase (a feldspar), hornblende, and pyroxene. Because the latter two contain considerable iron, the gabbroic gneiss boulders typically have a rusty-brown surface weathering rind up to ¼ inch thick. These gabbroic rocks and the poorly exposed graphitic gneiss are the oldest rocks present within the boundaries of the park and historic site. In fact, at approximately 1 billion years old, the gabbroic gneiss is one of the most ancient rocks in Pennsylvania. PLEASE DO NOT REMOVE ANY ROCKS FROM THIS AREA, AS IT IS PART OF THE NATIONAL HISTORIC SITE.

(2) Chestnut Hill-Millers Point-Mill Creek

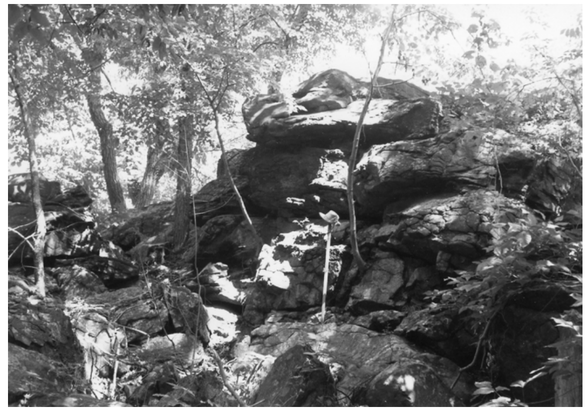
The rugged and wooded eastern portion of the park—underlain entirely by Triassic- and Jurassic-age sedimentary and igneous rocks—is readily accessible from numerous fairly well marked trails. All of the features noted below can be seen by making a 5¼-mile hike in a loop that begins and ends at the Y-intersection of Pa. Route 345 and Shed Road in the northwest corner of Hopewell Furnace National Historic Site (see the location and geologic map).

A small boulder field occurs along the power line and in the adjacent woods at F, about 100 feet north of Mill Creek Trail. The boulders are pale-red quartz conglomerate and conglomeratic sandstone of the Hammer

Creek Formation. Most of the boulders are somewhat rounded; most range in size from 6 inches to 3 feet, but a few are as much as 6 feet in diameter. The larger ones are conglomerate, and the smaller ones are pebbly sandstone. Note the rounded quartz pebbles and cobbles that are commonly concentrated into distinct bands on the boulder surfaces; these are the stratification planes which indicate that the layers of gravel and sand were successively laid down in an ancient streambed. A similar boulder field can be seen just north of Mill Creek Trail about 1,600 feet east of F near the summit of Chestnut Hill (G). These are but two of the numerous conglomerate-boulder fields on gentle slopes of hills underlain by the Hammer Creek Formation. All appear to result mainly from the frost-induced breakup of thick, discontinuous beds of conglomerate and coarse sandstone originally deposited as sand and gravel in the channels of Triassic streams.

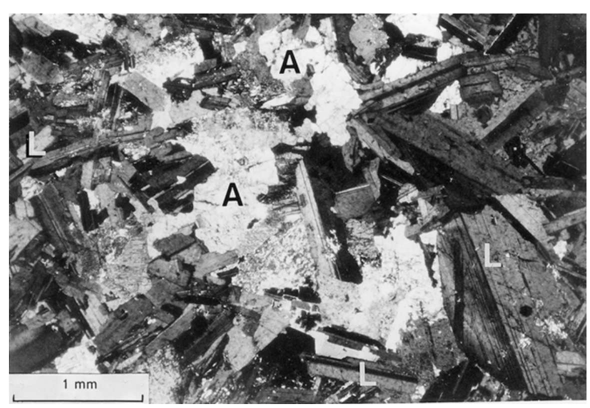
Boulder field of Hammer Creek conglomerate beneath the power line on the west slope of Chestnut Hill (F).

Millers Point (H) is a spectacular rocky crag of diabase on the edge of a ragged escarpment overlooking the Schuylkill River valley 3,600 feet northeast of the crest of Chestnut Hill. The once solid diabase ledge here has been broken into a pile of huge detached blocks, most of which are 10 feet or more in diameter. This has been accomplished largely by frost action and tree wedging within natural fractures in the rock mass.



Diabase crag at Millers Point (H).

Some of the fractures are now open wide enough for a person to walk between adjacent blocks. The diabase itself is a hard, dark-gray, crystalline rock composed of the minerals labradorite (a plagioclase feldspar) and augite (a pyroxene). The two minerals crystallized together as the rock cooled from the molten state. Because the diabase cooled at a rather rapid, but uniform, rate at considerable depth within the earth's crust, the crystals formed were relatively small and about equal in size. Like the gabbroic gneiss boulders at E, the diabase blocks and boulders weather with a rusty surface rind due mainly to the oxidation of iron in the pyroxene. Many diabase blocks also exhibit a distinctive polygonal network of surface cracks resembling a "turtle shell." These fractures



Microscope photograph of the minerals in a piece of diabase from a closed quarry on Sixpenny Creek (A, augite; L, labradorite).

represent **shrinkage cracks** that originally formed as the diabase cooled at depth from a molten magma to a solid rock; they have since been accentuated by surface weathering. The hill slope north of Millers Point is strewn with somewhat angular to partially rounded blocks of diabase, many of which have broken from the bedrock crag and moved downslope under the force of gravity.

At I and J, on the Mill Creek Trail east of Mill Creek, excellent examples of **root wedging** can be observed in several of the many diabase boulders that lie on the ground. At both places, gray birch trees 8 to 16 inches in diameter growing out of cracks in large, rounded diabase boulders tell an interesting story. Several tens of years ago, a seed fell into the bit of soil that existed in the fracture of the rock and started to grow. Seeking nourishment for the growth of the tree, the roots followed the fracture downward. As the root grew in diameter, it exerted enough power to force the initially narrow crack open, splitting the rock into several pieces. This demonstrates how plant growth is related to the normal geologic processes of weathering and rock disintegration.

The diabase of Millers Point (H) and Mill Creek valley (I and J) is part of the Morgantown pluton, a great bowl-shaped body of intrusive rock that crops out around the eastern and northern edges of the park and occurs at a depth of about 1 mile in the vicinity of Hopewell Lake. The boundary of the pluton north of Millers Point is a large fault along which rocks on the south side have been dropped down relative to rocks on the north side (see the geologic cross section). Southeast of the park, the outcropping edge of the pluton makes a sharp turn through St. Peters and continues in a westerly direction to Morgantown. The diabase was at one time extensively quarried as a source of dimension stone and aggregate. At St. Peters, 1.5 miles southeast of the park, the French Creek Granite Company operated a dimension-stone quarry that was first opened in 1885. When polished, the diabase made an attractive dark stone for ornamental and architectural use. The polished rock was marketed as “black granite.”

Root wedging in diabase boulder along Mill Creek Trail in Mill Creek valley (I).

(3) Hopewell Furnace

Hopewell Furnace, which dates from 1771, was one of several charcoal-iron blast furnaces erected during the eighteenth and early nineteenth centuries to utilize the magnetite iron ores associated with the Morgantown pluton. Others included Warwick Furnace (1737) in Warwick, Chester County, and Joanna Furnace (1792) north of Morgantown, Berks County. Hopewell’s halcyon days lasted mainly from 1825 to 1844, during which time it produced thousands of cast-iron stoves as well as many thousands of “pigs” that were turned into wrought-iron products at local forges. The furnace was “blown out” for the last time in 1883.

Hopewell Furnace (restored).

Iron ore for the Hopewell Furnace was obtained mostly from three nearby mines: (1) the Hopewell mine on the south side of Thomas Hill, about 1 mile south of the park; (2) the Jones mine, between Elverson and Joanna, about 1½ miles southwest of the park; and (3) the Warwick mine, just south of Pa. Route 23 at Warwick, 2 miles south of the park. Iron commonly makes up 50 to 60 percent of this ore and occurs chiefly as the mineral **magnetite** (Fe_3O_4), the "lodestone" of ancient mariners. Other minerals in the ore include **calcite** ($CaCO_3$), the major component of limestone, and **pyrite** (FeS_2), better known as "fool's gold." Good examples of magnetite ore can be seen in a rock pile adjacent to the furnace at the National Historic Site. The best place to collect ore specimens is from the old mine dumps at the site of the French Creek mines at St. Peters, 3 miles southeast of Hopewell Furnace. Two underground mines at this site, one of which was worked to a depth of 1,250 feet, provided ore to several iron furnaces in the area, including Hopewell, between about 1850 and 1928.

In 1948, Bethlehem Steel Corporation detected a large magnetite ore body adjacent to the Morgantown pluton through the use of recently devised aeromagnetic methods. This discovery resulted in the 1958 opening of the Grace mine in the hills north of Morgantown, Berks County, 5 miles west of the park. At the time the mine closed in 1977, ore was being extracted from shafts more than 3,000 feet deep. Total production at the Grace mine amounted to approximately 45 million tons, and much ore reportedly still remains at depth.

The iron ores at all of the mines mentioned above formed by the replacement of limy rocks (chiefly limestone or marble) by hot, iron-rich, gaseous and watery solutions associated with the crystallizing magma of the Morgantown pluton.

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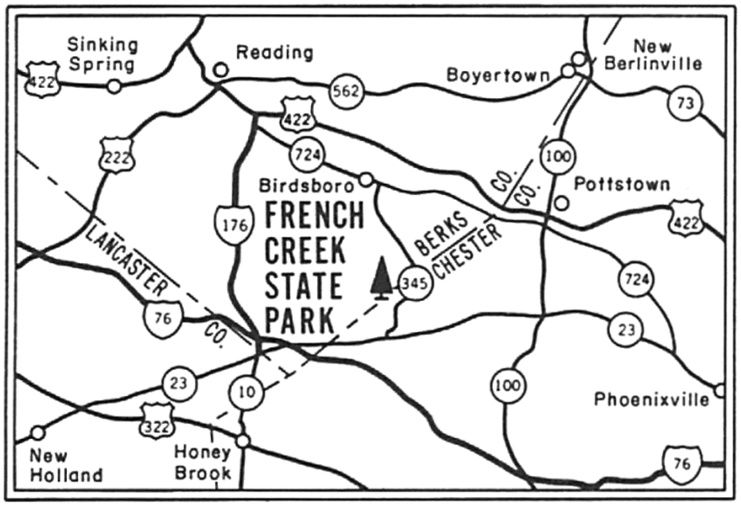

LOCATION MAP

French Creek State Park
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