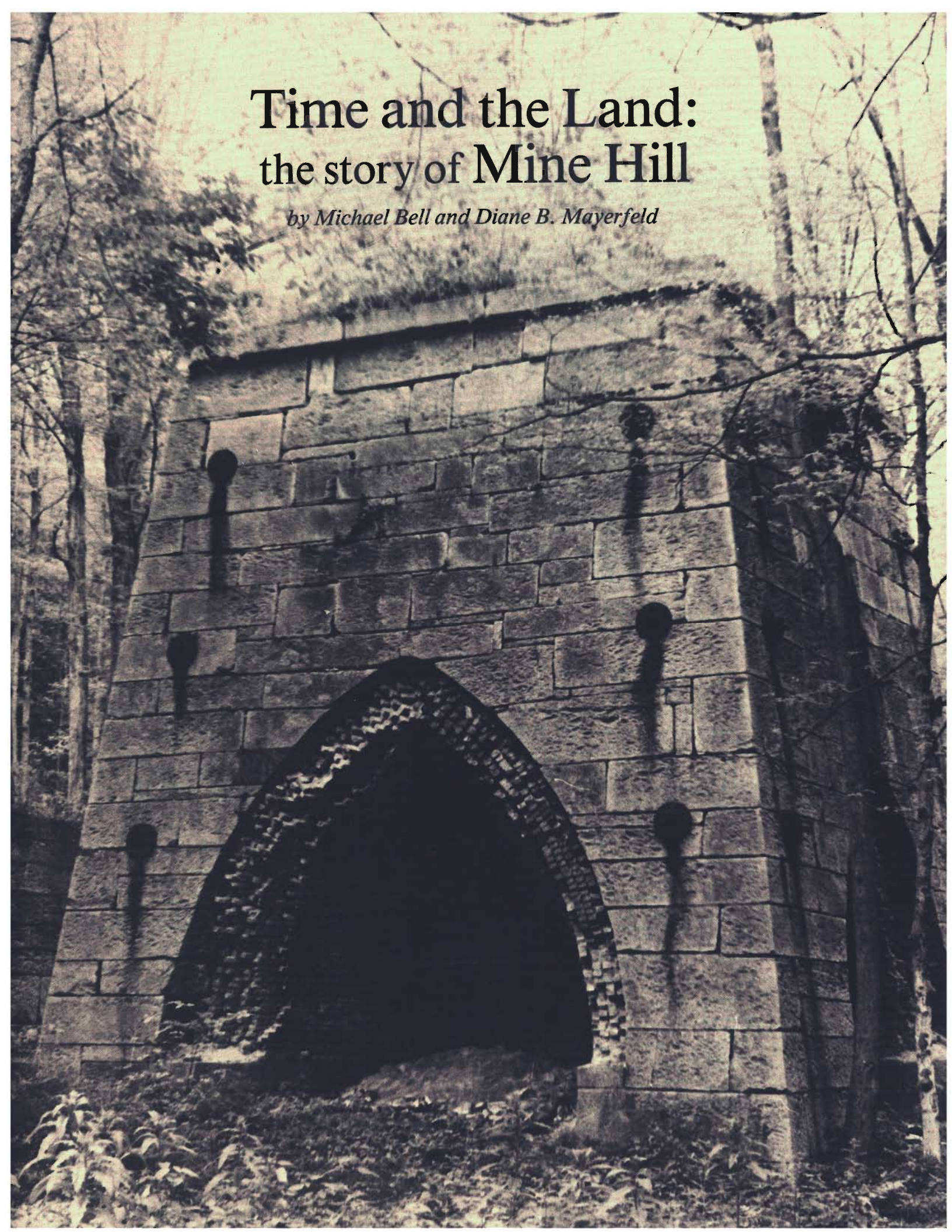


Time and the Land: the story of Mine Hill

by Michael Bell and Diane B. Mayerfeld



This book is dedicated to the memory of Wilbur Shook, former president of the Roxbury Land Trust, friend of Mine Hill and all who knew him.



Many people contributed to the preparation of this report. Dr. Thomas G. Siccama, who decided that this project would be “a winner,” guided us through the bogs of research and helped us slog through the final write-up.

Fred Chesson gave us the benefit of his long acquaintance with Mine Hill and joined us in discovering more about its history.

Greg Yovan and Les Mehrhoff showed us animals and plants that had been under our noses all along, and Larry Kershner spent many long hours printing the photographs used in this publication.

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A bibliography for this report is available from the Roxbury Land Trust.

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by
Michael Bell
and
Diane B. Mayerfeld

wildlife photography by Greg Yovan

Roxbury Land Trust
and
Yale School of Forestry and Environmental Studies

1982

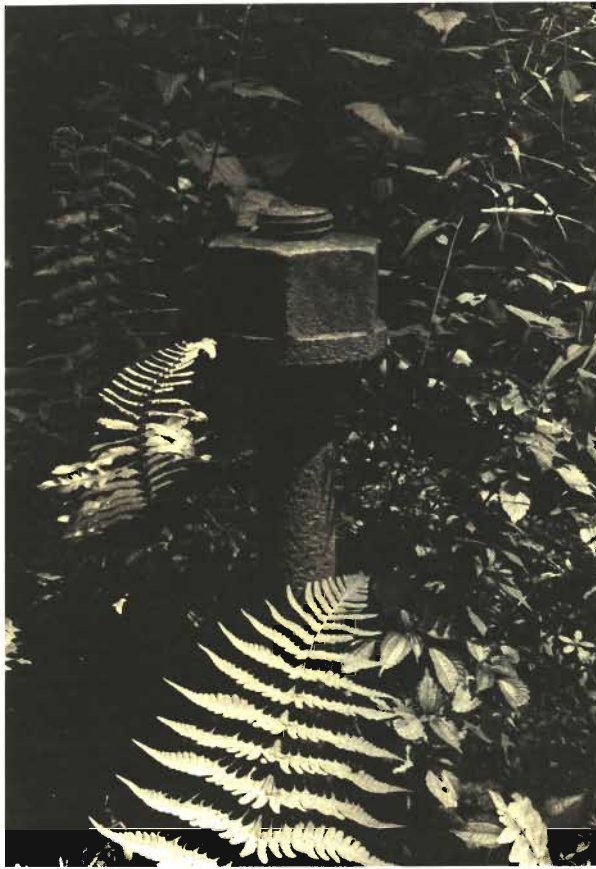


Photo: Greg Yovan



Photo: Greg Yovan

Only within the last one hundred years have we begun to recognize the effect of people on the land. Formerly, urbanization, industrialization, and agriculture were seen only in terms of human needs while their effects on wildlife and plantlife went unlamented or unnoticed. But now that irreversible changes in natural systems threaten the quality of life, the preservation of land and living things is also regarded as a human need. Located in rapidly developing western Connecticut, Mine Hill Preserve can play an important role in the protection of our natural heritage.

Ironically, the beautiful oak and hemlock forests of Mine Hill have grown over remains from an industry that is central to the level of human control over the environment. Over a hundred years ago, an iron mining and steel manufacturing venture scarred the hill and stripped it of its trees. The mine tunnels, the blast furnace, and other traces of that period in the hill's history testify to the need and power of humans to change their environment. Today, however, the forest has reclaimed the land and healed most of the scars, demonstrating that the damage done by our use of the natural world is not necessarily irreparable.

The history of Mine Hill actually begins over 500 million years ago, with the geologic forces that laid the foundations for all the natural processes and human activities that have shaped the hill. Thus, this report begins with the geologic history of the area. The next section of the report concentrates on ecology, and the final part discusses the human history of Mine Hill.



Geology

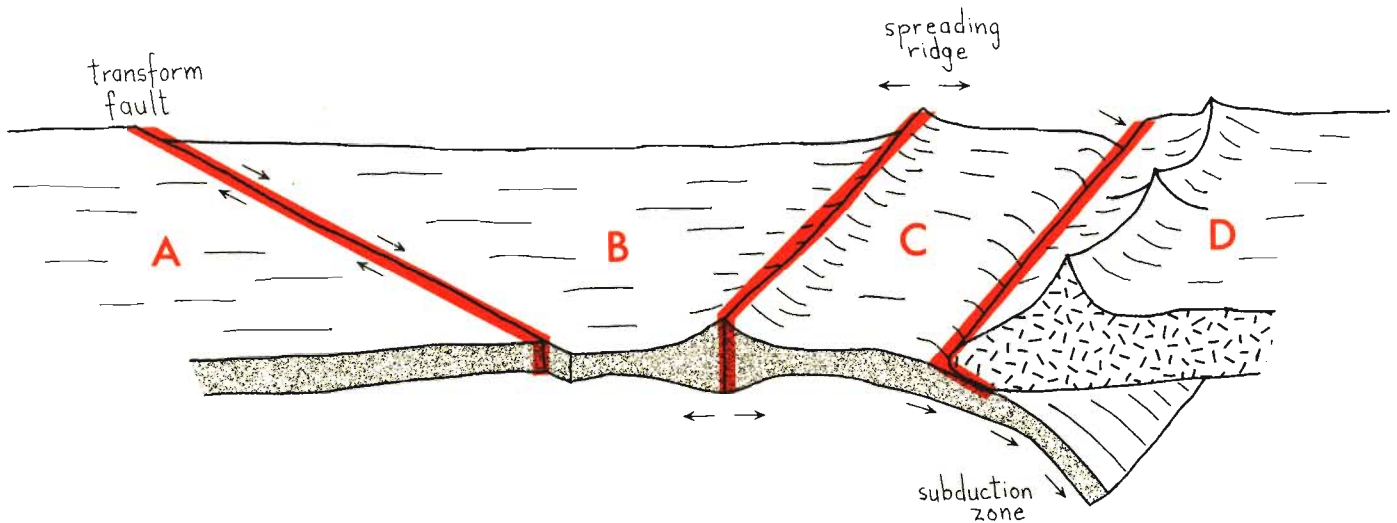


Figure 1: The relationships between four hypothetical plates: A, B, C & D

Mine Hill lies in an exciting region of modern geologic research. The hard crystalline rocks that form the core of the hills and the softer rocks that underlie the valleys of western Connecticut have long puzzled geologists. It is only within the last decade that researchers have begun to understand the events which long ago formed the region. The key which is finally unlocking these geological mysteries is the theory of *plate tectonics* (or, as it was formerly called, continental drift).

The theory of plate tectonics suggests that the surface of the earth is comprised of a dozen or more independently moving pieces called *plates* (see Fig. 1). The interactions of these plates have shaped all the large scale features of the earth's surface. When they move past each other great tears in the earth are formed, such as the San Andreas Fault in California. These tears are known as *transform faults*. Places where plates move away from each other appear on the surface as submerged oceanic mountain chains called *spreading ridges*. When plates move under or over each other long trenches form; these trenches, the deepest places in the oceans, are called *subduction zones*. Unfortunately, plates do not move past each other easily. They bump and grind along their edges, making transform faults, spreading ridges, and

subduction zones the sites of very intense and hazardous earthquake activity.

The other great force on the earth's surface is water. In either liquid or solid form, as a river or as a glacier, water is the master sculptor which shapes the ridges and valleys. Water is also the most important factor in the phenomenon of *weathering*. Weathering is the process that turns rocks into clay and, when combined with the carrying and carving capacity of rivers and glaciers, turns lofty mountains into low hills.

Plate tectonics and the action of water combine to create the three main types of rocks: *igneous*, *metamorphic*, and *sedimentary* (see Fig. 2). Igneous rocks (from the Latin word for fire) are rocks that were at some time in a hot molten state. This includes the lavas and ash falls that come out of a volcano (called *extrusive* igneous rocks) and the molten magma which feeds a volcano but never reaches the surface (called *intrusive* igneous rocks). The high heat and pressure of deep burial beneath the surface of the earth may cause rocks to take on a new texture or chemical composition; these changed rocks are called metamorphic (from the Greek and Latin for transformation). The third type of rocks, sedimentary rocks, are formed by the deposition and cementation of eroded material derived from igneous, metamorphic, or other sedimentary rock.

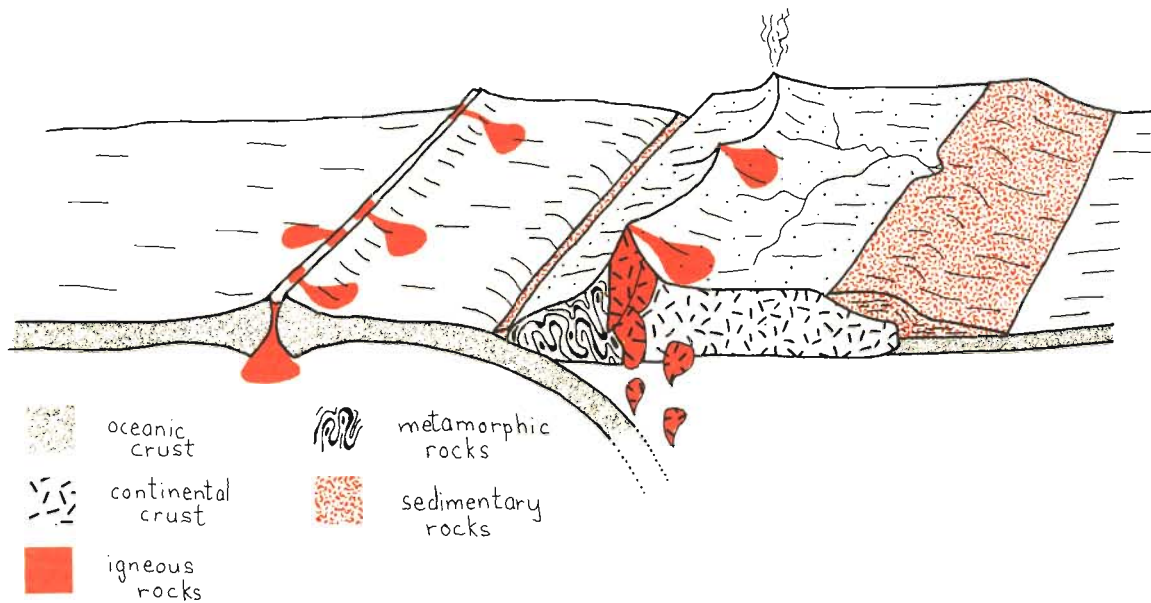


Figure 2: The formation of igneous, metamorphic, and sedimentary rocks by moving plates

Igneous rocks are principally formed where plates move away from each other (spreading ridges), and metamorphic as well as igneous rocks form where plates move toward each other (subduction zones). Along spreading ridges, hot magma wells up from inside the earth to fill the space left by plates moving away from each other. When this magma cools, it solidifies into igneous rocks such as basalt and gabbro.

When new material is added along the ridges, a corresponding amount of old material must be consumed in subduction zones. Hence, the heavier portions of the subducted plates are incorporated into the earth's interior. The lighter portions rise up in huge molten blobs of magma and intrude into the overlying plate. When this magma cools and solidifies, it forms igneous rocks such as granite and diorite. If it reaches the surface, volcanoes are born and extrusive igneous rocks are deposited.

Subduction zones are also zones of very high pressure (because the plates are pushing towards each other). These pressures lead to the formation of metamorphic rocks. Subduction zones also lead to the formation of sedimentary rocks. The compressive forces and volcanism push up mountain belts which are eroded into the raw material needed for the formation of sedimentary rocks.



The Geologic History of Southern New England

Long ago, the present location of Mine Hill was probably deep ocean. The explanation of how southern New England was transformed from ocean to continent is a great achievement of plate tectonic theory. Although

the interpretation of many pieces of the puzzle is still being debated, the overall history as shown in Figures 3a to 3f is now agreed upon by most geologists.

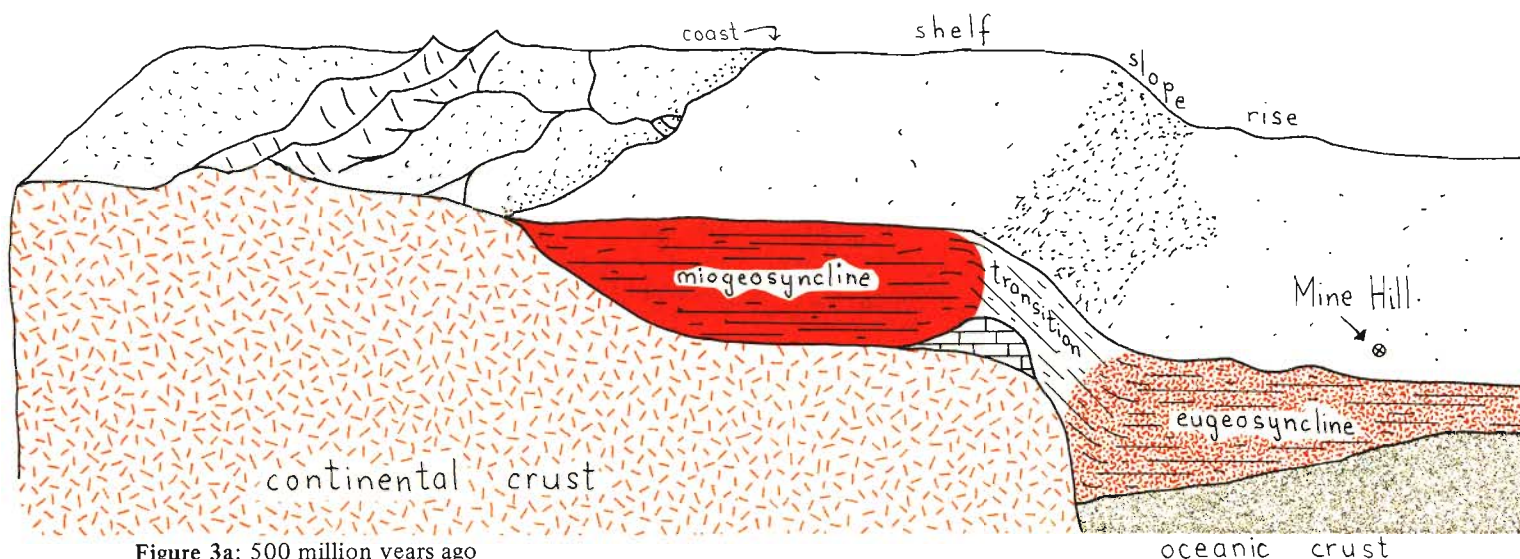


Figure 3a: 500 million years ago

Five hundred million years ago, southern New England probably resembled the Atlantic coast off North Carolina today. Along the shelf, shallow water marine sediments were deposited, forming limestones, sandstones, and sandy shales. These regions of shallow water shelf deposits are called *miogeosynclines*. Off the shelf on the continental rise deep water sediments such as black shales and silty shales were deposited in what is called a *eugeosyncline*. The transition zone along the shelf edge between the miogeosyncline and the eugeosyncline retained less sediment because of the steepness of the slope. The marine sediment from different depths and slopes can still be recognized

in the metamorphic rocks of New England.

Although the coastline and continental shelf of 500 million years ago may have resembled those of today, other aspects of ancient geography were very different. For example, what is now the eastern coast of North America was then the southern coast. North America was also much closer to the equator and the climate was probably tropical. In addition, there was a small continent between North America and the Euroafrican land masses. This small continent is now known as Avalonia and, as we shall see below, can still be visited today.

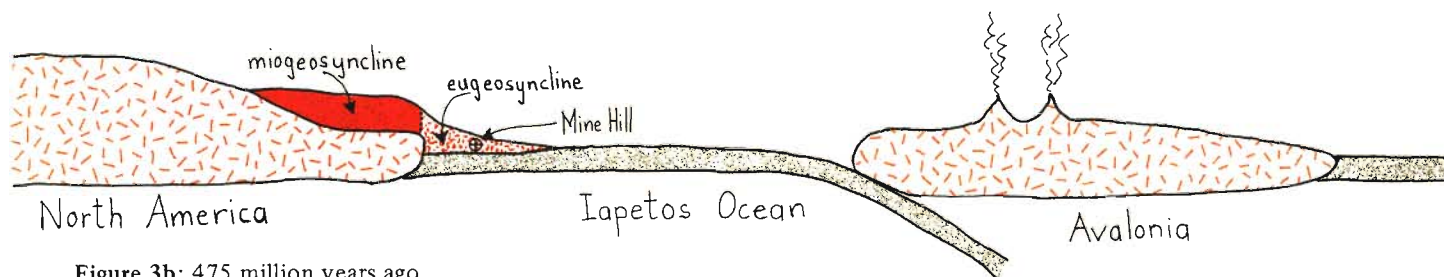


Figure 3b: 475 million years ago

About 475 million years ago, the ocean between North America and Avalonia began to close. The ocean floor may have been subducted under Avalonia but researchers have not yet found conclusive evidence.

Geologists have named this ocean the Iapetus Ocean after the mythical father of Atlas, for whom the Atlantic Ocean is named.

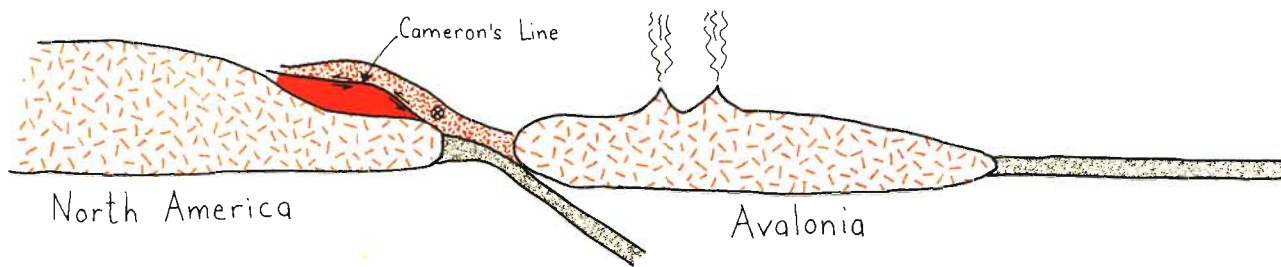


Figure 3c: 450 million years ago – the Taconic Orogeny

By 450 million years ago, a process known as *obduction* had begun. Obduction occurs when the ocean floor is pushed over instead of under a continent, thrusting huge kilometers - wide chunks of rock great distances landward. As a result, the transition zone was squeezed out and the eugeosyncline shoved on top of the miogeosyncline along a thrust fault known

today as Cameron's Line. The enormous pressures created by the obduction process then began folding and metamorphosing all of the rocks along the continental margin. This period of thrusting, folding, and metamorphism is called the Taconic Orogeny and was the first stage in the building of the Appalachian Mountain Belt.

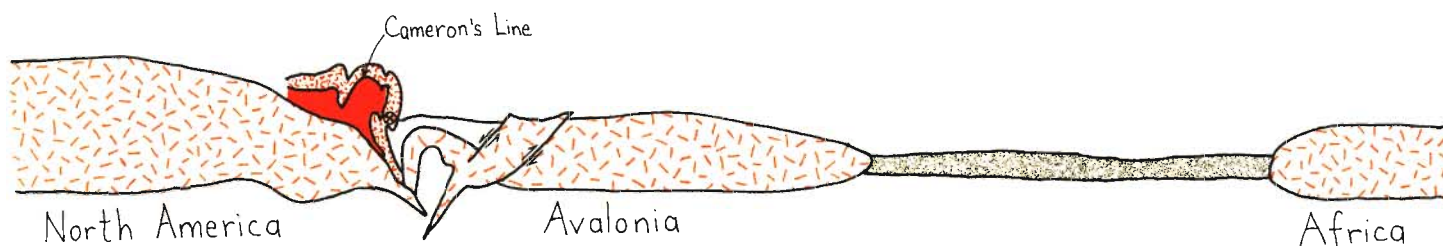


Figure 3d: 360 million years ago – the Acadian Orogeny

Around 360 million years ago the Appalachian Mountain Belt experienced another period of intense folding and metamorphism called the Acadian Orogeny. Folds from the Taconic Orogeny were refolded, metamorphosed rocks were remetamorphosed, and granitic masses were intruded (including the Mine

Hill Granite Gneiss), greatly complicating the geology of southern New England. This phase of mountain building appears to have been caused by the collision of North America and Avalonia and completed the closing of the Iapetus Ocean.



Figure 3e: 260 million years ago – the Allegheny Orogeny and first rifting episode

Following the Acadian Orogeny came the first of three periods of rifting when continental blocks that were colliding tried instead to pull apart. This led to the formation of the Boston and Narragansett Basins, broad, flat valleys that filled with sediments eroded from the surrounding hills. Beginning about 260 million years ago, rifting ceased and was replaced by the final period of mountain building in the Appalachians. This period, known as the Allegheny Orogeny, was

caused by the collision of Africa with North America. The collision caused yet another phase of folding and metamorphism, this time mostly to the east in Rhode Island and eastern Connecticut; there is little evidence of the collision in western Connecticut. This last mountain building event was part of the great gathering together of all the continents into the super-continent of Pangea.

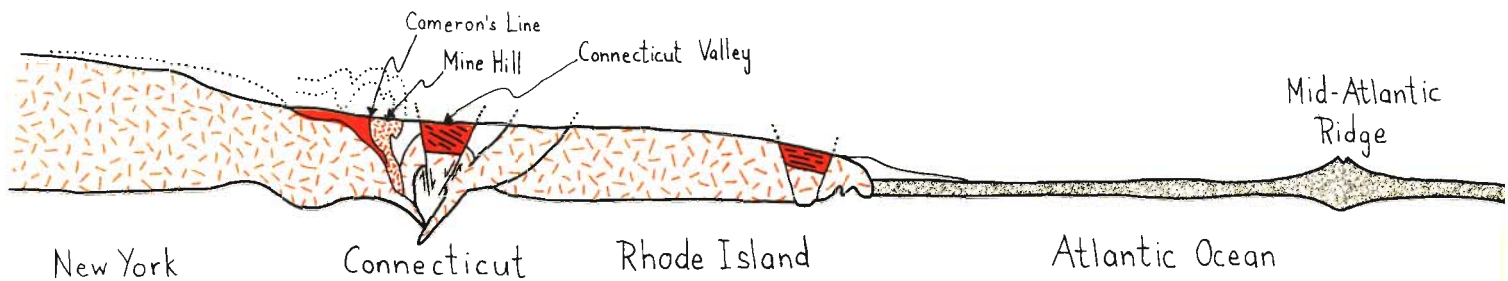


Figure 3f: Southern New England today

About 225 million years ago, the second period of rifting started as a new ocean began growing between North America and Avalonia. But this ocean was not to be and rifting stopped, leaving behind the sediment-filled Connecticut Valley. The third and final period of rifting began 180 million years ago as a new ocean tried once again to grow, this time between Africa and Avalonia, leaving Avalonia welded onto North America. This attempt proved successful and eventually formed the Atlantic Ocean which is continuing to grow wider today at a rate of about 2 centimeters every year. Avalonia has remained a part of North America and now includes all of Rhode

Island, the eastern strip of Connecticut, and southeastern Massachusetts. The rocks of the miogeosyncline and the eugeosyncline between ancient Avalonia and the Housatonic Highlands are all that remains of the Iapetos Ocean. Although it has been severely folded, Cameron's Line is still an important feature in Connecticut's geology because it marks the precise junction between the miogeosyncline and the eugeosyncline. It also indicates the approximate location of the continental shelf edge during the geologic past when east was south and the Atlantic was the Iapetos.

The Geology of Mine Hill

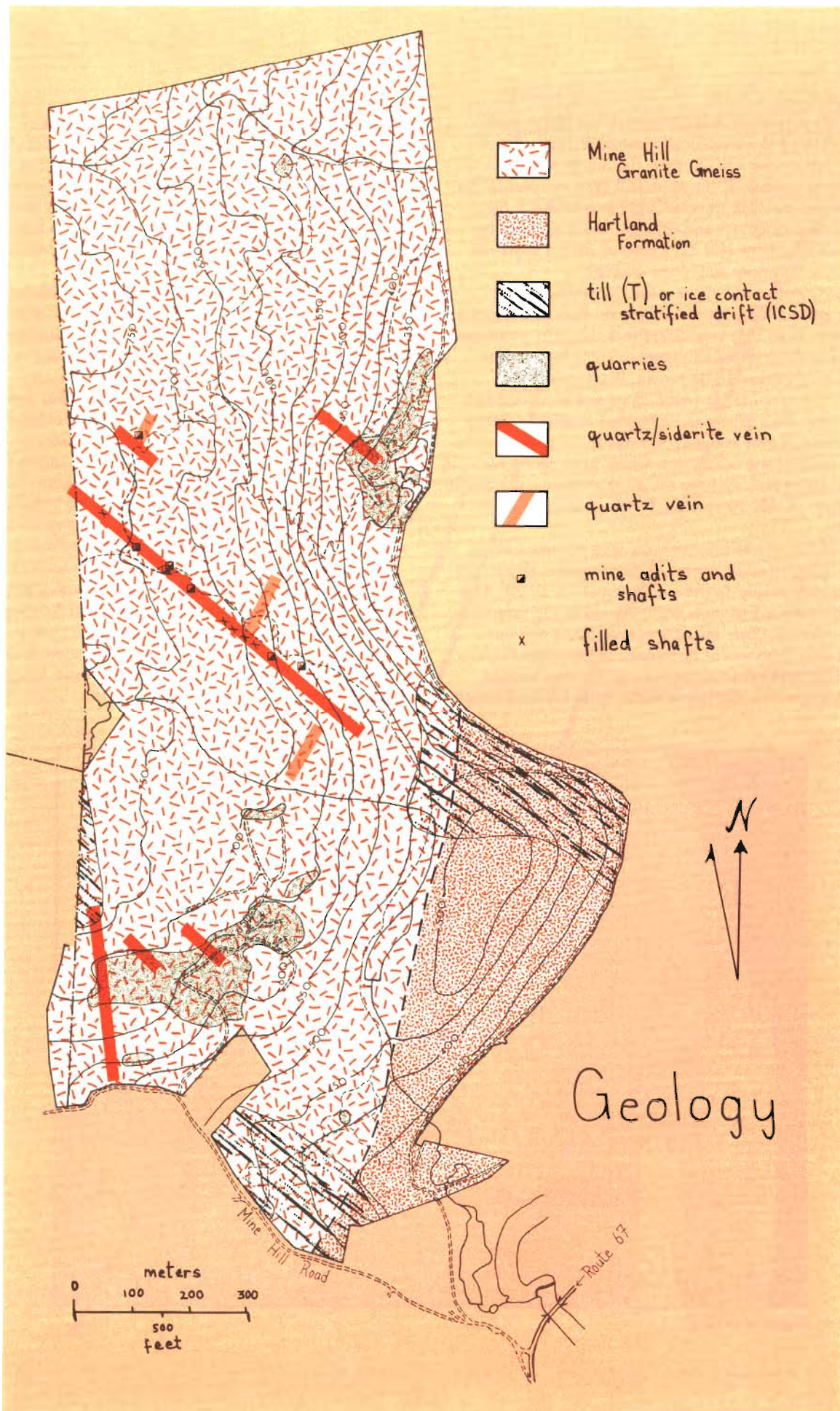
Mine Hill is located just east of Cameron's Line in the strongly metamorphosed deep-water eugeosynclinal sediments of the Iapetos Ocean (Figs. 3f and 4). Most of the preserve is underlain by the Mine Hill Granite Gneiss, a 360 million year old rock containing feldspar, quartz, and mica. Because the mica and other minerals are all aligned in the same direction, the rock is called a granite gneiss instead of a granite. Although it clearly had an igneous origin, the aligned (or gneissic) character of the rock indicates that at the time of intrusion the whole region was still under strong pressure, forcing the minerals to grow parallel to each other. In a way, the Mine Hill Granite Gneiss is both an igneous and a metamorphic rock.

The only other rocks within the preserve are part of the Hartland Formation (see Geology Map). Hartland Formation rocks are primarily extremely metamorphosed sediments from the eugeosyncline and show a wide variety of compositions and appearances. They range from a mica-rich quartzite (metamorphosed sandy shale) that looks very similar to the Mine Hill Granite Gneiss to a schist (metamorphosed black shale) that crumbles easily in one's hand.

The Quartz-Siderite Veins

Striking northwest/southwest across Mine Hill in the granite gneiss are the well-known quartz-siderite veins. These veins are famous for the wide variety of minerals they contain and for the beautiful specimens that have been collected from them. The best known of these minerals, siderite (iron carbonate), was the object of the mid-19th century iron mining efforts. Galena (lead sulphide) was also mined from the veins for its lead and for the small quantity of silver it sometimes contains. Some of the other minerals that are commonly found are quartz (silica oxide), pyrite (iron sulphide), goethite (hydrous iron oxide), and limonite (weakly crystalline goethite). Rarely, the minerals malachite (hydrous copper carbonate), loellingite (nickel iron arsenide), and bismutite (bismuth carbonate) are also collected. In all, a total of 32 different minerals have been reported from these veins.

Over the last 200 years at least 7 different quartz-siderite veins have been identified on Mine Hill. Tunnels have been cut on three of these veins. The most extensive mining and tunnelling was done on the largest known vein, where three horizontal tunnels (adits) and numerous vertical shafts (stopes) were put



in (see Tunnel Map). A short tunnel, the North Adit, was excavated in a vein located north of the main mining operations and another, the South Adit, was dug in a vein south of the Mine Hill Preserve. Numerous shallow test pits and trenches were dug to check for the presence of quartz and siderite, and these may be found all over Mine Hill. Outcrops of several veins can be seen in the upper and lower quarries.

Near the openings of the adits and shafts are ore dumps and rubble piles which contain beautiful mineral specimens from the veins. Siderite is the most prominent mineral in these piles and ranges in color from cream to a shining copper kettle brown. Black sphalerite with tiny hints of red is found alone and in association with silvery-blue galena all embedded in siderite. Many single large pyrites in the intriguing crystal shapes called pyritohedrons and octohedrons have been found but are becoming rare. Perhaps the most attractive specimens are masses of siderite sprinkled with gleaming yellow pyrites.

All of the quartz-siderite veins were intruded along minor faults trending northwest/southeast at about 120° and dipping steeply to the southwest at 75° to 90° . The pattern of the intrusion is well exposed in the tunnels in the old vein. Close inspection reveals not one but several vein members of different compositions running parallel to each other so that as a group they appear to be a single vein varying in width from $1/2$ to 3 meters.

Any one vein member may range in composition from pure quartz to nearly pure siderite to a mixture of both and may run for only a few meters or more than 100 meters. In several places, one or more vein members split off from the main vein to form a branch or a parallel vein. This pattern is best observed in the lowest adit where the tunnel intersects three side veins to the main vein.

The origin and formation of the quartz-siderite veins is not yet certain and no explanations have yet been published. However, it is probably not a coincidence that the igneous veins of Mine Hill are so close to the sedimentary iron deposits found near Salisbury, Connecticut. One possible explanation is that thermal activity associated with the intense metamorphism of the Acadian Orogeny may have caused a buried deposit similar to the Salisbury ores to be remobilized and injected above as veins. This process would be possible if deformation of Cameron's Line had, through recumbent folding or thrusting, placed a portion of the Stockbridge-Inwood marble belt with a sedimentary iron carbonate member beneath the Hartland Formation. This explanation, is however, extremely speculative and there is little geologic evidence on Mine Hill to support or deny it. The only piece of evidence that can be established with certainty at the present time is that since the veins intrude the Mine Hill Granite Gneiss, they must be younger than it.

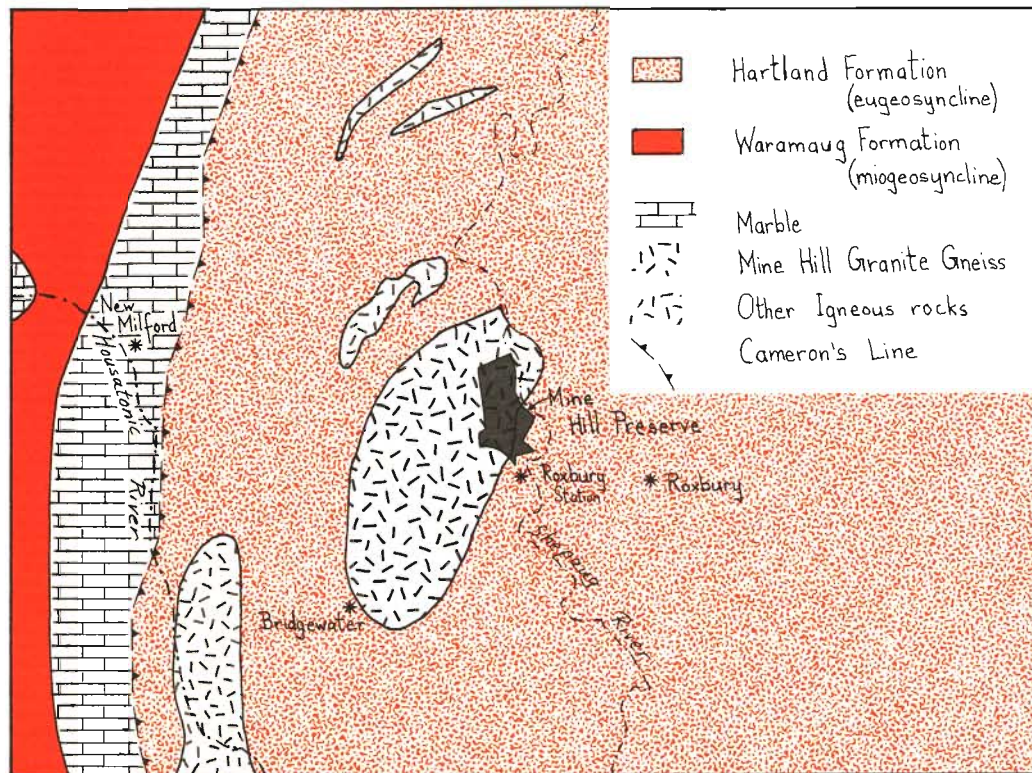
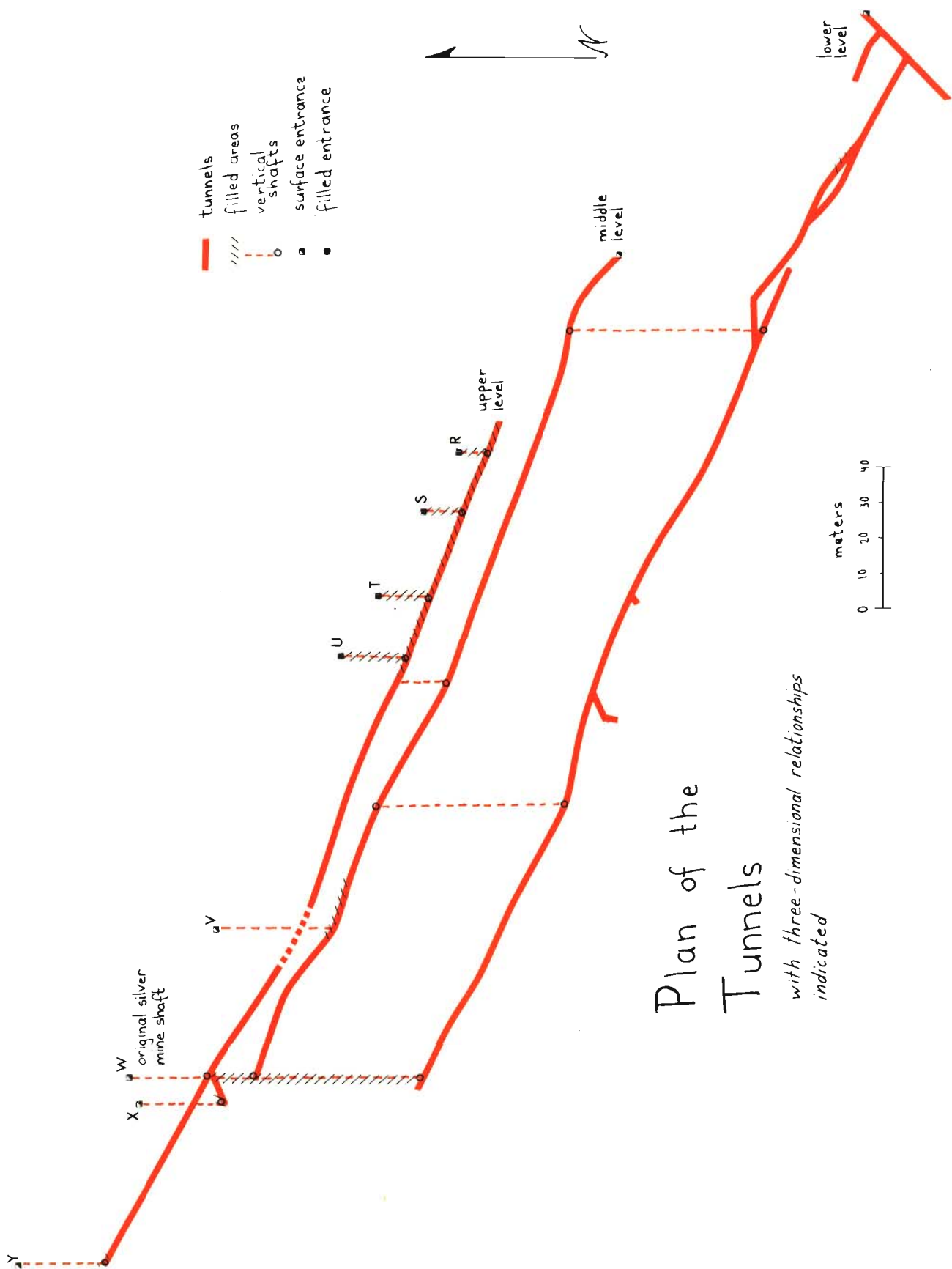


Figure 4: Regional geology



Plan of the
Tunnels
with three-dimensional relationships
indicated



The Quartz Veins

Five veins of almost pure quartz were also mined on the hill, three of which are on the preserve's property (see Geology Map). Unfortunately, there are no known historical records of this episode of Mine Hill's mining history. Most likely, the quartz was used in glassmaking, ceramics, and paint manufacture.

Four of the quartz veins trend at about 205° and the fifth, associated with the north adit, trends at 235° . Their geologic origin may be related to the origin of the quartz-siderite veins. However, because they seem to be cut off by quartz-siderite veins in two places (near shaft S and in the North Adit), the quartz veins probably formed in an earlier geologic time.

The Granite Gneiss Quarries

In addition to harboring the famous quartz-siderite veins and the lesser known quartz veins, the Mine Hill Granite Gneiss has also had economic importance as a building stone. Seven separate quarries have been excavated on the Mine Hill Preserve (see Geology Map), and at least one other has been dug in the granite gneiss off the preserve. Two of these quarries are still active but only on a limited basis with an annual production of about 1500 tons. Although it once saw use primarily as "dimension stone" for bridges and buildings, it is now sold as facing stone, flag stone, mantel pieces, and wall stone.

The desirability of the Mine Hill Granite Gneiss is largely due to its attractive uniform blue-grey color and its workability. The gneissic character of the rock gives it a pronounced "rift," which allows the rock to be split into any required size. Along the rift, the granite can be split with two or three well-placed blows from a sledge hammer. Perpendicular to the rift, however, is what quarrymen call the "hardway," which must be drilled if it is to be split. The normal technique for handling the hardway is to drill a series of short holes 10 to 12 centimeters apart, fill each hole with a wedge and two "feathers," and carefully tap each wedge once down and back along the line of drill holes until the rock cracks.

Another reason that the Mine Hill Granite Gneiss was so popular in the past is the enormous pieces that can be quarried from it. The limiting factor in the size of quarried stone is the distance between the thin cracks, called joints, that run through all bedrock. Joints form in two principal ways; either as minute faults caused by the pressures of mountain building events or from the release of pressures due to the removal of overlying rock by erosion and glaciation (joints due to removal of overlying rock are given the special name sheeting joints). According to a local story, the joints are so far apart in the Mine Hill Granite Gneiss that a piece was once removed so large that it took two weeks to load on the train and two railroad cars to transport it.



The History of Glaciation

The climate of the earth is strongly affected by the shape, size, and position of continents, and the height and position of mountain ranges. Thus, as North America grew larger, constructed mountain ranges along its edges, moved north, and turned counter-clockwise during the last 500 million years, the climate changed with it. The steady tropical climate of the past is now a temperate one which experiences alternating warm and cold periods on an approximately 100,000 year cycle. Cold periods cause great ice sheets to advance and warm periods (such as the present) force the ice to retreat once again.

The explanation of the periodicity of glacial advances was worked out in the late 1800s by James Croll, a Scotsman, and in the early 1900s by Milutin Milankovitch, a Yugoslavian. However, this theory became generally accepted only in the past four or five years. Milankovitch and Croll suggested that the slight variations in the earth's orbit around the sun and the slight wobble in the spin of the axis cause enough change in the amount of solar radiation received to touch off a glacial advance. Recent investigations in all the oceans of the world have found conclusive evidence of these glacial cycles and have shown that glaciation began in North America over 5 million years ago. The size of glacial advances increased around 3 million years ago and since that time there have probably been 25 to 30 major glaciations of North America.

Glaciation on Mine Hill

The only ice sheet of which there is a record in southern New England retreated around 14,000 years ago. It is impossible to say how many other ice sheets have reached here because the eroding power of a glacier usually wipes clean any evidence of earlier glaciations. But there is abundant evidence of the Wisconsin Ice Sheet, as the most recent glacial advance is called. Like a great white bulldozer it plowed through New England, pushing a long mound of debris in front of it. When the Wisconsin Ice melted back from its maximum extent, this mound was left to form a low sand ridge called a *terminal moraine*, part of which we know today as Long Island. In addition to the debris it pushed in front, the glacier also carried crushed sand and rock inside the ice. This material, called *drift*, was dumped all over New England when the ice melted.

The Mine Hill Preserve is covered by thick drift in three places: on top of the hill, along Mine Hill Road, and on a small area just south of the lower quarry. The drift on top of the hill is part of a streamlined elongate mound, called a *drumlin*, that probably formed at

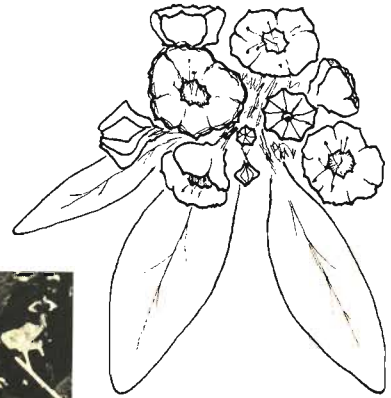
the bottom of the Wisconsin Ice Sheet while it was advancing. This drift and the glacial sediment along Mine Hill Road are both examples of *till*, an unsorted assortment of rocks and pebbles of all sizes. The drift south of the lower quarry is an example of *ice contact stratified drift* that was deposited by water flowing along the contact of the hill and the ice while the glacier was melting.

Most of the rest of the preserve is blanketed by shallow discontinuous patches of till and loose pieces of frost-cracked blocks of Mine Hill Granite Gneiss and Hartland Formation metamorphics. These pieces were probably broken off the bedrock during the first few thousand years after the glacial retreat when permafrost conditions prevailed in southern New England. The rounded edges and weathered surfaces of these tabular rocks distinguish them from the fresh appearance of rubble left over from mining and quarrying on the hill.

Mine Hill is currently undergoing very little geologic change. No significant erosion or earthquake activity is occurring now. Probably the next geologic event to have an important effect on Mine Hill will be the return of an ice sheet about 25,000 years in the future.



Ecology



Red tail hawk

Photo: Greg Yovan

Mine Hill is by no means a pristine woodland. From the 1750's to the 1870's mining, iron manufacture, and deforestation greatly altered the balance of nature on the hill. However, during the past hundred years Mine Hill has been subjected to very little human intervention, while most of Southern New England has undergone extensive development.

Today, the preserve's 360 acres support several different mature forest types and a diverse wildlife population, while most of the surrounding countryside is in residential, agricultural, or industrial use. Several rare and endangered plants grow here, and the hill may at least occasionally harbor rare animal species. However, the hill's ecological importance does not derive from its rare or endangered species, but rather

from its preservation of several representative New England habitat types. Together with Steep Rock Preserve and Judd's Bridge Farm to the north, Mine Hill is part of one of the largest protected natural areas in Connecticut.

The ecology of Mine Hill is not only shaped by its living resources, but is also the product of many abiotic factors. Some of the most important forces acting on the preserve are its *geology, climate, hydrology, and soils*.

The geology of Mine Hill, which strongly influences its climate, hydrology, and soils, and therefore its flora and fauna, is described in the previous section. Climate, hydrology, and soils are discussed below.

Climate

The climate of an area plays an important role in determining its vegetation and wildlife. Some plants tolerate wider temperature and moisture ranges than others, but all are best adapted to certain weather conditions. Climate also influences soil formation, the rate of erosion, and soil acidity. In general, moist, warm climates promote rapid weathering of bedrock and speed up soil formation. Since water is the primary agent of erosion, areas with periods of intense precipitation may be more susceptible to soil erosion than climates with year round, but light precipitation. Cold, moist climates tend to have more acidic soils than hot, dry climates.

On a worldwide scale, climate is determined by the distance and tilt of the earth's orbit around the sun and by the arrangement of the continents. On a more regional level, the principle determinants of an area's climate are its latitude, altitude, and topography. Mine Hill is located at 41° 35' North, in the middle of the temperate zone. The hill rises from 100 meters to 244 meters above sea level. The slope faces east, making the site slightly more shaded and therefore moister and cooler than a southern exposure in the same region. This part of New England receives about 115 to 130 centimeters of precipitation per year with a frost free season of about 125 to 135 days.

The ecology of small areas may vary greatly because of very localized differences in temperature and moisture, creating specialized *microclimates*. The shade cast by a single plant or rock may change the microclimate on a patch of ground enough to favor one type of plant over another. Thus, when the sun is out, the quarries on Mine Hill are considerably hotter and drier than the hemlock groves. One special microclimatic feature of Mine Hill is the nearly constant year round temperature and moisture in the mine tunnels.

Hydrology

The movement of water through an area can have a great effect on the plants and animals that will thrive there. The major factors influencing the hydrology of a site are climate, topography, geology, soil, and vegetation.

In New England, precipitation is distributed fairly evenly throughout the year. Nevertheless, the pattern of water movement through Mine Hill changes with the seasons. Usually, the amount of water visible in the streams and ponds of Mine Hill is highest in the spring when winter's accumulated snow thaws. Later, when the snow has all melted and the deciduous plants begin taking water from the soil to use in photosynthesis and transpiration, the water level drops, and several small streams dry up. Even in midsummer, though, a heavy rain may briefly raise the water level.

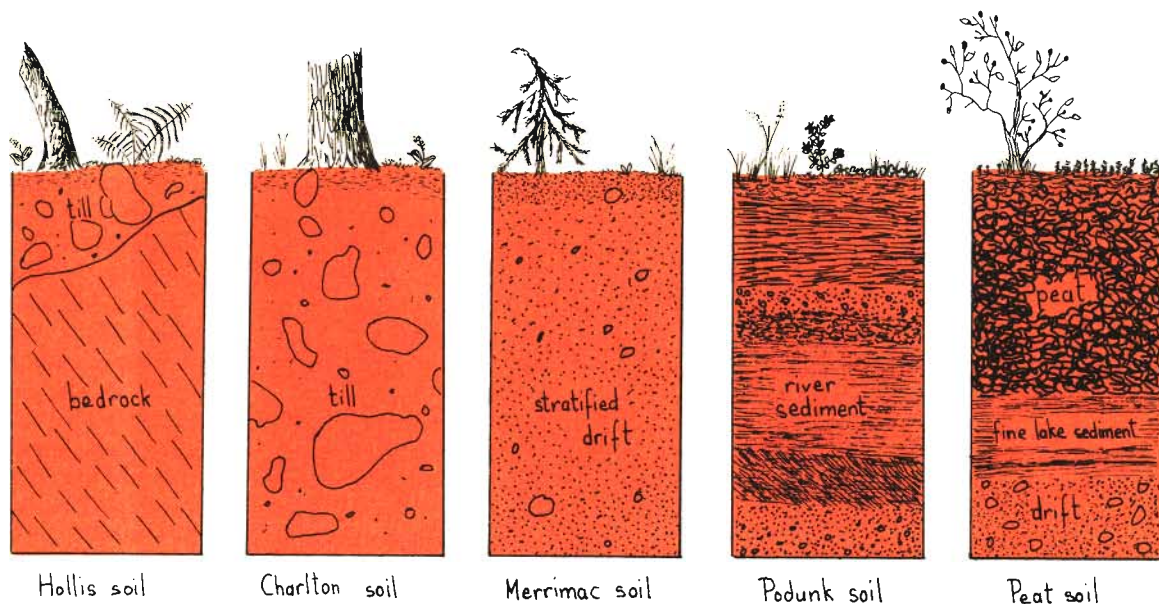
All the water in Mine Hill Preserve flows to the Shepaug River just outside the eastern boundary of the preserve. In a few areas, water collects in natural or man made basins. Although the water in these swamps and ponds appears to be motionless, it too is gradually flowing towards the river.

About 100 meters east of the bog on top of the hill, water emerges from the ground and runs into Mineral Spring Brook. This little tributary is the mineral spring that gives the brook its name. The water that issues from the ground here is stained a yellowish orange color and has a high iron and sulphur content. White streamers of sulphur-reducing bacteria sway in the flowing water, giving off a sulphurous odor. Early in the 19th century people thought that "chalybeate springs" such as this one had medicinal value, and the rocks lining the spring may have been placed there to allow easy collection of the supposed healing waters.

Most likely, the water for the spring comes from the bog. The iron and sulphur may be leached from the organic material at the bottom of the bog, or perhaps the water seeps through an underground mineral vein between the bog and the spring and leaches the iron and sulphur from the vein.



Photo: Greg Yovan



Representative Soil Profiles

Soils

Soil is the product of *parent material* and *organic matter*. Parent material, particles derived from weathered bedrock or other surficial geologic material, usually makes up the bulk of the soil. Mine Hill's soils are derived from four different types of parent material: bedrock, glacial drift, alluvial (river) sediments, and lacustrine (lake) sediments. Organic matter is produced from the vegetation growing in the parent material and is usually concentrated in the upper centimeters of the soil. Although it normally accounts for only a small percentage of total soil volume, organic matter often has an enormous effect on soil quality.

Unlike much of the surrounding countryside, most of Mine Hill is covered with little or no glacial drift. The shallow Hollis soil weathered from this thin scattering of drift (principally till) is well drained but very stony and uneven in depth. In many places outcrops of bedrock poke through the Hollis soil veneer. These soils are too rocky to clear, and the U. S. Soil Conservation Service classifies them as suitable for woodlands, recreation, or wildlife habitat, but not for cultivation.

On the western edge of the preserve, along Mine Hill Road, and on the small hill north of the reservoir the glacier did deposit significant amounts of drift (see Geology Map). Accounts of the operations at Rockside Quarry suggest that drift may also have originally covered much of the lower quarry area. This glacial debris weathered to form soil that is moderately well drained to somewhat excessively drained, deep, and fairly rocky. Although it is stony, this soil can be farmed if the largest rocks are removed.

In the moist bottomlands bordering Mine Hill the parent material for the soil is mainly sediment from the Shepaug River. Here, the soil is quite deep, not rocky, and moderately well to poorly drained. The Soil Conservation Service describes these soils as being suited for forest, pasture, or occasionally cultivated crops such as silage corn.

Finally, in those areas where standing water retards decomposition by restricting the supply of oxygen, the soils consist almost exclusively of partly decomposed organic matter accumulated over many years. The very poorly drained soil of the bog at the top of the hill developed above glacial lake sediments.

Vegetation History

The abiotic parameters of an ecosystem; its geology, climate, hydrology, and soils; appear stable and unchanging in the context of a human lifetime, but over the centuries any of these factors can shift drastically, and with it the entire ecosystem. The ecology of Mine Hill is always changing, although many of the changes are too gradual to become noticeable over the course of a year or even a century. Changes in vegetation patterns occur somewhat more rapidly, some as a result of the alteration of abiotic factors and some in response to other forces including stochastic (unpredictable) natural events, such as hurricanes and fire, and human intervention.

One can place the beginning of the history of vegetation in New England at the end of the most recent ice age. When the glacier retreated it left behind a barren land, for no plants could survive under the massive ice sheet. As the ground was exposed and the climate became warmer, certain hardy species established themselves in the wake of the retreating ice. As conditions changed further, partly because of climatic changes and partly because of the effects of the early vegetation, new species crowded out the original plants.

The sequence of plants establishing themselves in an area devoid of vegetation is called *primary succession*, and the first plant types to establish themselves in such an area are referred to as *pioneer species*.

Pollen grains preserved for thousands of years in peat bogs provide clues to the sequence of plant

communities that followed the retreat of the glacier. The earliest vegetation resembled that of the modern tundra. A boreal spruce-fir forest eventually replaced the tundra vegetation and was in turn superceded by more southern species such as beech, birch, and red and white pines. The warming trend continued until about four thousand years ago, when the dominant vegetation types in northwestern Connecticut were oak, beech, and hemlock forests. Since then, the climate has cooled slightly, so that warmth loving species such as oak and hickory today grow best in southern Connecticut but more cold adapted species such as pine, spruce, sugar maple, and white and yellow birch thrive in the northern part of the state. The northern species extend their range south on the colder northern and eastern exposures, while the southern plants may be found further north on southern and western slopes.

For more than 10,000 years, but particularly in the last 300 years, human activities have greatly influenced the vegetation of the region and of Mine Hill. American Indians probably set fire to areas of forest to improve game habitat and visibility for hunting. Although Native Americans did farm in Southern New England, it is extremely unlikely that they ever cultivated crops on Mine Hill.

European settlers farmed the till soils on the western edge of Mine Hill. These rocky fields were abandoned long ago, but the effects of farming can still be seen in the fully regrown forest. When land that



Immature great horned owl

Photo: Greg Yovan

has been cultivated for several years is abandoned, primary succession occurs on a small scale. Common pioneer species on abandoned fields in southern New England include grasses and sedges, red cedar, white pine, and grey birch. Which of these species predominates depends on which seed sources are present when the field is abandoned. With the exception of white pine, these species soon die out when the hardwood forest invades. A few moribund grey and hybrid grey and white birches are the last surviving pioneer species in the once farmed areas of Mine Hill Preserve.

On the rest of Mine Hill the soil was too steep and rocky for successful cultivation, but nearby residents doubtlessly logged the land to get lumber for construction, firewood, and charcoal. An aerial view of Mine Hill shows that many of the different vegetation associations in the Mine Hill Preserve occur in rectangular plots whose borders do not follow any natural ecological boundaries or old field lines. These rectangular plots may correspond to areas that were logged at different times in different ways.

Many of the species now growing on the hill were not originally American plants, but were introduced from Europe or Asia. Introduced species include many attractive wildflowers that thrive along the lower quarry road, around the furnaces, and in the quarries. Some of these plants simply add new colors to the landscape without greatly changing the balance of native flora, but others such as Japanese honeysuckle can crowd out many native species.

Several insects and fungi imported from Europe and Asia have had devastating impacts on American forests. From around 1910 to 1920 the chestnut blight killed almost all the American chestnut trees in New England. This fungus arrived in the United States around 1900 on Chinese chestnut seedlings imported from Asia. The blight kills the above-ground portions of the trees but leaves the roots alive. Today, there are many young root sprouts from this majestic tree on Mine Hill, indicating that it once was one of the dominant species. Unfortunately, the blight invariably destroys the young

trees before they reach maturity. Until 1981 one of the largest American chestnuts in Connecticut and one of the very few which produced fruits in the wild lived on the Mine Hill Preserve. Located on the road leading from the river to the donkey path, this tree now has also succumbed.

Another Eurasian fungus which attacks American trees is the Dutch elm disease. This disease, which requires an insect carrier, has not spread as widely as the chestnut blight, which relies mainly on wind dissemination. There are still many healthy American and slippery elms on Mine Hill.

The gypsy moth, which was brought to the United States to breed silk worms, is another serious forest pest. The population of this insect fluctuates widely in a boom and bust pattern. When the population is high, gypsy moth caterpillars may defoliate entire forests. Defoliation makes deciduous trees very susceptible to drought and disease, and certain species such as white oaks and chestnut oaks frequently die as a result. The skeletons of oaks killed during the gypsy moth population peak of 1971 are scattered all over Mine Hill, and the defoliation resulting from the enormous caterpillar populations of 1980 and 1981 will undoubtedly also yield many dead oaks. The caterpillars eat coniferous trees only when their preferred deciduous species have been consumed, but heavily defoliated evergreen trees, particularly hemlocks, have little ability to recover. Young hemlocks are especially susceptible, and many have already died.

Although forest fires may occur naturally, certain human activities increase the incidence of fire considerably. Some longstanding residents of Roxbury report that forest fires set off by the trains periodically swept the hill late in the 19th and early in the 20th century. Pieces of charcoal in the soil northeast of the reservoir indicate that fires burned that area, but the majestic hemlock stands near the center of the preserve have not been exposed to fire since those trees began growing over 90 years ago. Hemlocks are extremely vulnerable to fire, and the young trees could not have survived a conflagration.



Yellow warbler feeding chick

Photo: Greg Yovan

Current Vegetation Patterns

Today, several classic New England plant communities grow on Mine Hill. The vegetation map shows six categories of vegetation associations. To a certain extent the classification of different vegetation associations is arbitrary. No two areas are exactly alike, and the boundaries between different vegetation communities are often gradual transitions from one species association to another.

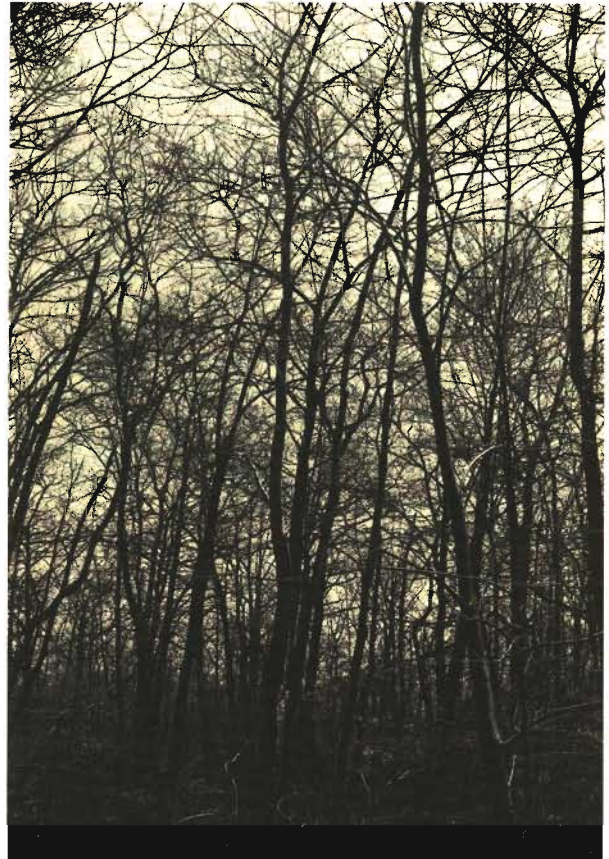
The Hardwood Forest

More than 25 species of hardwood trees grow on Mine Hill. Some, like red maple, grow wherever any deciduous tree can survive, while others have more rigorous requirements and grow only in certain locations on the hill. The hardwood stands can be broadly classified in two categories: the moist bottomland sites and the drier upland areas.

Along most of the eastern border of Mine Hill Preserve the soil is moist and the topography relatively level. In some spots where the topography in fact forms a depression, there is seasonally standing water and only swamp vegetation survives, and in other places periodic clearing has left this strip of moist soil overgrown with brush and vines. But over much of this area tall shagbark and bitternut hickories, white ash, basswoods, and sugar maples form a deep green canopy. Understory trees and tall shrubs such as maleberries, nannyberries, shadbush, and spicebush thrive in the light filtering through the main canopy. A wealth of non-woody plants carpets the forest floor.

The upland hardwoods, particularly the dry oak stands along the western border of the preserve, are very different from the hardwoods at the foot of the hill. On the ridge one finds predominantly oak trees: chestnut oaks, red oaks, a few black oaks, and white oaks. Scattered red maples and black birch also grow here. None of these trees reach the 25 and 30 meter heights attained by the hickories and ashes of the bottomlands. Because the ridge is so dry, most of the oaks are only about 15 meters tall. In moister areas on Mine Hill, the same species of oaks and black birch can easily attain heights of 25 meters and more.

The underbrush in the upland hardwood forest is very variable. The main shrub is mountain laurel, but lowbush blueberries grow profusely in some areas. In areas of mountain laurel and blueberry growth, the shrub statum may reach 70% occupancy, but elsewhere the shrubs take up less than 10% of the available space.



Gypsy moth defoliation on Mine Hill, June 1981

These laurel thickets produce beautiful blossoms in early summer, but they often use up so much of the growing space that they suppress other shrubs and young trees.

The Hemlock-Hardwoods Forest

In some of the hardwood areas of intermediate moisture, many hemlocks are scattered through the stand. In some instances the hemlocks cluster together in small clumps; in other areas individual hemlocks grow among the oaks and other hardwoods. Often the hemlocks form an understory, with the hemlock crowns just touching the bottom of the canopy of the taller hardwoods. When one of the taller trees dies and creates a hole in the canopy, the hemlocks quickly grow into the freed space. The hemlock-hardwood stands in which the hemlocks form an understory will one day evolve into pure stands of mature hemlock, unless some outside force such as fire, disease, or human intervention interrupts this trend.

The Hemlock Forest

On much of Mine Hill, especially near the lower quarry, hemlocks completely dominate the forest. The hemlock is the most shade tolerant tree in southern New England, and it is also the most effective tree at screening out sunlight. The pure hemlock groves are perhaps the most impressive looking and oldest stands on Mine Hill. Trees over 60 centimeters in diameter are not uncommon. Because they are so effective at blocking light, mature hemlock stands have almost no shrubs or herbaceous plants growing beneath them. Not even hemlocks can survive long under a closed canopy of hemlock. A few black and yellow birch and red and white oaks survive in the hemlock woods as long as their foliage stays above that of the conifers. The hemlocks tend to predominate on very steep slopes that were not accessible for logging and in moist areas that have escaped fire.

The Quarries

In an aerial view the larger quarries on Mine Hill stand out clearly as areas with no vegetation. These mounds of large stone blocks and packed beds of crushed rock are not conducive to plant growth. On the ground, however, there is a dramatic demonstration of primary succession as the forest gradually manages to invade these little wastelands.

In the center of the quarry, only lichens and some mosses can survive, but closer to the surrounding forest other small plants appear. Bush clover, meadowsweet, rabbitclover, and other hardy wildflowers grow on this exposed, stony ground. Perhaps the nitrogen fixing ability of legumes accounts for the high proportion of flowers in the clover and pea family surviving in this poor soil. Closer still to the edge of the quarried area, black willows, grey and black birch seedlings, cottonwoods, and pin cherries find a foothold. Where the piles of quarry rubble are shaded by the surrounding forest or by a nearby cliff face, hemlocks and black birch form the invading forest.

Wetlands

Several areas on Mine Hill have seasonally standing water. These wetlands have distinctive vegetation types, since only a few species can survive in the oxygen-poor, acidic soils of such areas. Although some of the same species appear in each of the wetlands on the preserve, the various wet areas are by no means identical.

The Peat Bog

The bog at the center of the western boundary of the preserve once was a little lake, which over the millennia has filled in with organic and inorganic sediments. Towards the center of the bog the peat (soil matter composed primarily of organic material in various stages of decomposition) is over 3 meters thick. Underlying the peat is a layer of sand and gravel that may have a glacial origin. Today this bog supports a normal New England acid bog plant community: sphagnum moss, buttonbush, winterberry, leatherleaf, and red maples. The largest red maples are dead, which may indicate that the water level has risen in the past few years. On drier soils around the edge of the bog one finds acid loving shrubs such as azaleas and highbush blueberries.

The Reservoir

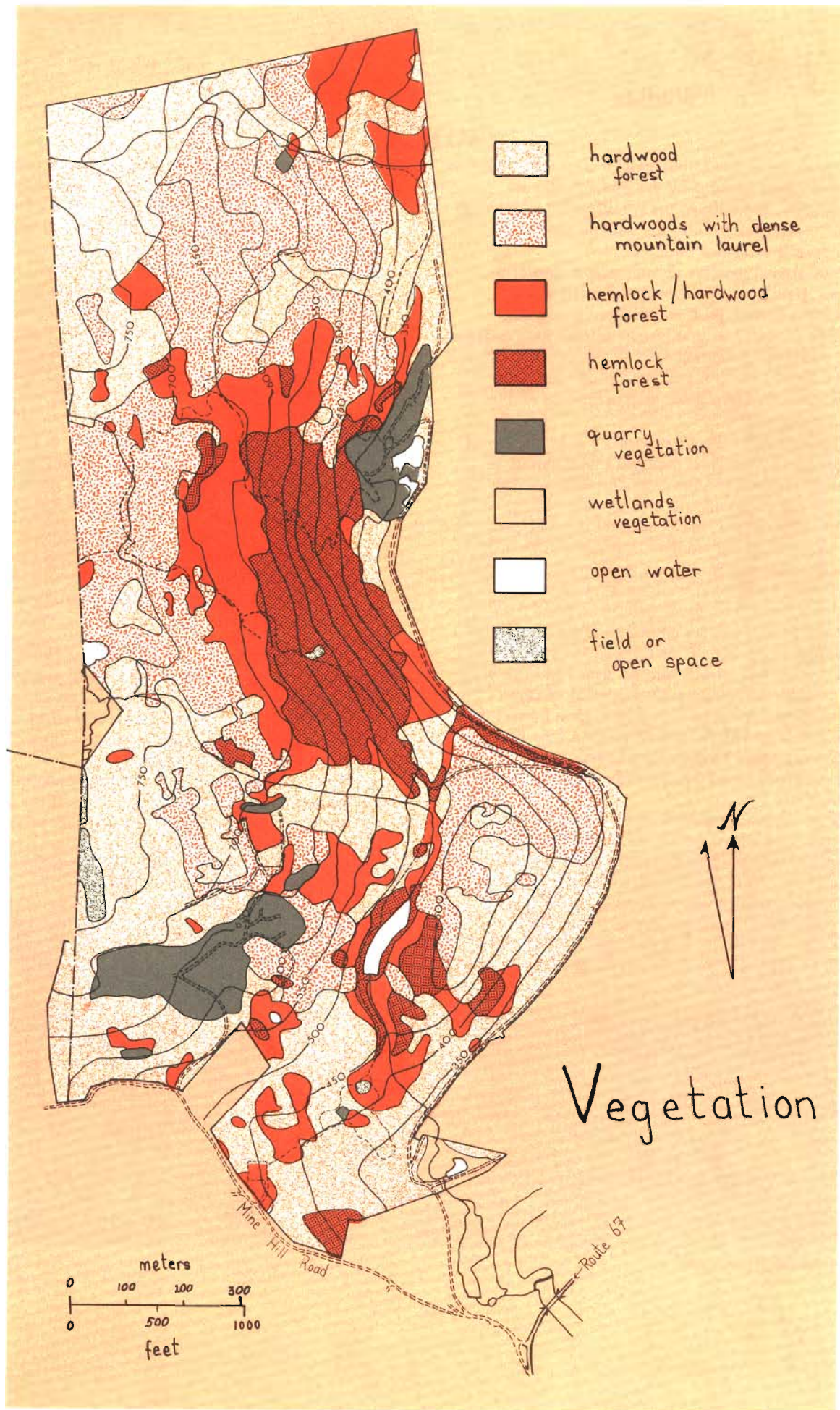
This little pond was created in the middle of the 19th century when the proprietors of the iron mine dammed Mineral Spring Brook to create a permanent water supply. The reservoir contains water year round, but it has silted in a little over the years, and burr reeds now grow in the shallower sections. A few wetland species such as buttonbush grow around the edge of the water.

Two Swamps

Along the eastern edge of the property the soil is much moister than elsewhere on the property. The slight depression in which this moister ground occurs may have been caused by a former course of the Shepaug River. In two areas here, human intervention has impeded surface drainage enough to create spots of swamp vegetation.

Just south of the lower quarry and west of the road the ground is waterlogged or even submerged all year. A map drawn in 1854 shows this area as an artificial pond with a dam at the southern end. Rubble from the lower quarry now fills most of this former pond, and the rest has silted in considerably, but the drainage is still too poor to support anything but wetland vegetation. Burr reeds, arrowheads, and marsh grasses grow where the water is deepest. Sphagnum moss, buttonbush, winterberry, and highbush blueberry occupy the rest of this swamp.

At the southern end of the preserve where the property extends east towards the former Shepaug Valley Railroad, the old railroad spur to the loading dock near the furnace obstructs the course of Mineral Spring Brook, creating another wetland. The center of this swampy area is a little marsh with burr reeds, rice cut grass, arrowheads, and St. Johnswort. Buttonbush, winterberry, quillwort, cattle parsnip, and other wetland species grow around the edge of the marsh.



Wildlife

Just as the vegetation of an area must adapt itself to the conditions imposed by the geology, climate, topography, and soils, so the wildlife must adapt itself to the vegetation. In turn, the wildlife may have a considerable influence on the flora.

Each animal requires an appropriate *habitat* to survive. Habitat can be thought of as the space containing enough food and shelter to meet the animal's needs. Clearly, different animals have different food and shelter requirements. In general, large animals need a larger area to subsist than small ones, and predators need more space than herbivores of comparable size.

The Mine Hill Preserve supports a large number of species partly because it contains a wide variety of different vegetation types and habitats and partly because it includes enough area to support large predators. Moreover, the Mine Hill Preserve is part of a long corridor of wooded land stretching north along the Shepaug River from Roxbury Station to the Steep Rock Preserve in Washington, Connecticut.

In past years, bobcats have lived on Mine Hill. Bobcats are shy, solitary animals that are becoming increasingly rare as they are trapped for their furs. Although no bobcat was seen on Mine Hill in 1981, it is possible that they have temporarily changed territories and will return. A pair of great horned owls nested on Mine Hill for several years. A bear has also been seen passing through the preserve. More common predators such as red and grey fox also hunt and breed on Mine Hill.

Large tracts of mature forest are vital for the survival of smaller species, as well as the more spectacular predators. Several kinds of migratory songbirds, particularly certain warblers and vireos, must nest away from cleared areas to escape predation by cowbirds. Small openings such as a wide trail or a powerline right-of-way can provide a corridor giving cowbirds and other "edge species" unbridled access to the interior of the forest.

More than 100 species of birds summer on Mine Hill, and many more migrate through. The Lower Quarry Road is an excellent place from which to observe many of these species.

The Shepaug River and the agricultural fields east of the Mine Hill Preserve are two important complementary habitats to the upland forest of Mine Hill. Deer, mice, voles, and other herbivores find the cornfields to be a good supplementary food source, and predators hunt a variety of species along the river.

One special wildlife resource of Mine Hill is its network of mine tunnels. These tunnels remain at a temperature of about 10° to 13°C (50° to 55°F) all year.

Partly because they provide a consistently cool but not cold, moist, dark environment, and partly because they receive few disturbances, these tunnels are a favored location for bat hibernation and possibly breeding. Currently, at least four species winter here: the pippistrel, the little brown bat, the big brown bat, and Keen's bat, which is listed as a rare species in Connecticut. A recent survey of the tunnels revealed an estimated 500 to 700 little brown and Keen's bats, about 25 pippistrels, and an undetermined number of big brown bats hibernating in the lowest level alone.

The Indiana bat, an endangered species, was seen in these mines in the 1940's, but has not been identified here recently. However, it is very similar in appearance to the little brown bat and Keen's bat, and its presence could easily have gone undetected. Only more research will tell whether this endangered species winters in the mine tunnels.

Future Ecological Trends

In coming years, the ecology of Mine Hill will continue to change. Some trends can be predicted, but there is always the possibility that an unforeseen occurrence or unrecognized factor will affect the course of events. These changes may be caused by both human and natural influences.

Despite the inevitability of future human influences on Mine Hill, the ecological importance of the preserve will grow as the surrounding area becomes increasingly developed. The hill may eventually support several species not currently found there, if other habitats in the state are destroyed and some animals from those areas take refuge in the Mine Hill Preserve.

In today's industrialized world, the preservation of natural areas is crucial for psychological as well as ecological reasons. As the last large tracts of forested land in southern New England disappear, the value of Mine Hill will grow as an important element in the preservation of our biological heritage.

History

The Mine Hill of today is a haven for wildlife and a place for humans to escape from the pressures of urban life. However, the observant visitor will soon note that this has not always been so. In the latter half of the 19th century Mine Hill was no island of nature, but a busy, noisy, and smoky industrial center. The traces of man's quest for profit cover the hill, from clues as obvious as a blast furnace and huge heaps of quarry rubble to signs as subtle as a cluster of young hemlocks in the middle of a hardwood forest.

Where Highway 67 now crosses the Shepaug River a small community formed around the mining and quarrying activities. This thriving little town once supported a post office, a general store, a school, a lumber yard, a coal yard, a creamery, a hattery, a cigar factory, a brass factory, a hotel, several boarding houses, a bar, and a railroad station. Today the general store has been converted to a private home, the cigar factory

to an antique store, and the railroad station to a warehouse. Most of the other buildings have disappeared, destroyed by fire or flood or salvaged for the construction of new buildings.

This little town now survives only in the memories of the area's oldest residents. Others know the word "Chalybes" merely as the name of a small road and do not realize that the name of this vanished town refers to an ancient Asian tribe of ironworkers and to the iron ore that provided the original reason for the town's existence.

The history of Mine Hill is very much a product of the hill's geology and ecology. Over the centuries this land has been used in many different ways, but people's activities on the hill have always been shaped by the physical attributes of the hill as well as the demands of their cultures.



Stone cutters at work in the Lower Quarry, ca. 1905

Photo: Joseph West

Presettlement History

Over 10,000 years ago, American Indians reached southern New England. The first people in this region were nomadic hunters and gatherers. About 7000 or 8000 years ago, when the climate had grown warmer and oaks and hemlocks dominated the forests, the early tribes began to depend more and more on gathering and eventually cultivating plants, although hunting and fishing remained vital sources of food.

No American Indian artifacts have been found on Mine Hill, but the discovery of a rich archaeological site just a few kilometers upstream on the Shepaug River shows that Native Americans inhabited this region at least 5000 years ago. Mine Hill was quite likely part of the hunting territory for the tribes living in the Shepaug Valley.

Colonial History

In 1673 the Pootatuck Indians, a branch of the Paugusset Tribe, sold some land along the Pomerag River to a group of colonists from Stratford, Connecticut. During the next twenty years, these English settlers bought the land of present day Woodbury, Southbury, Roxbury, and other towns from this subsidiary of the great Algonquin Tribe.

Woodbury, which included Mine Hill until the town of Roxbury was incorporated in 1796, was primarily a farming community. During the 18th and early 19th centuries almost all of the land in Connecticut was farmed or at least used for pasture. Only after the federal government and the railroads opened up the flat, rockless, fertile soils of the midwest did New England farmers abandon their land and allow it to revert to forest.

The land around Mine Hill was not portioned out for settlement until early in the 18th century. The records indicate that at first Mine Hill (then known as Spruce Hill) was set aside as common land. Even by the uncritical standards of the 18th century yankee farmer, the rocky eastern slope was too stony and steep to plow or pasture. Only on the till soil at the top of the hill do old stone walls mark the locations of earlier fields and meadows. The hill was almost certainly logged for both building lumber and fuelwood, but very early on, the colonists noted the presence of commercially valuable minerals.

Silver and Lead

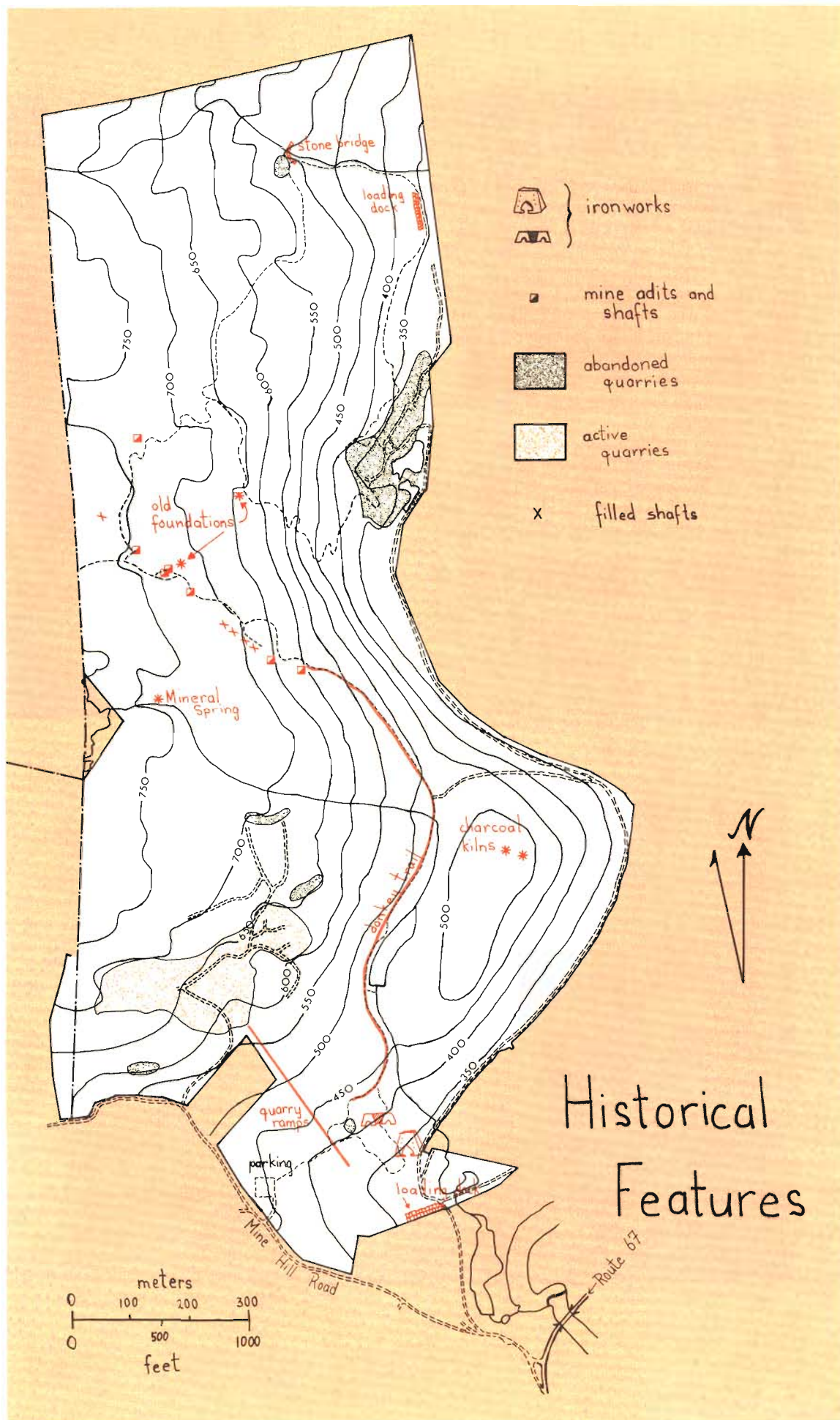
Possibly as early as 1724, but certainly by 1750, some enterprising individuals observed outcrops of mineral veins cutting across Mine Hill. In 1751 Moses Hurlbut and Abel Hawley obtained a tract of land from the town for the purpose of mining. Soon afterwards, Abraham and Israel Brownson also acquired property on the hill, some of which was laid out jointly to them and Hawley and Hurlbut, and some of which they owned exclusively.

It was the Brownsons who first decided to mine the mineral resources of the hill with a large-scale operation. They sold stock in their enterprise and hired a German goldsmith named Feuchter to oversee the excavations. Under Feuchter's supervision, a vertical shaft was sunk to a depth of about 45 meters, with a parallel shaft for ventilation. Yet the mine does not seem to have yielded a profit, for the Brownsons soon fired Feuchter and closed down their mining business. According to legend, as the German goldsmith was leaving the area one of his boxes fell off the oxcart and broke open, revealing what appeared to be silver ingots. This reported incident gave rise to rumors that the mine had actually yielded considerable quantities of the precious metal, which had been embezzled by Feuchter.



Visitors at the site of the original silver mine

Photo: Fred Chesson

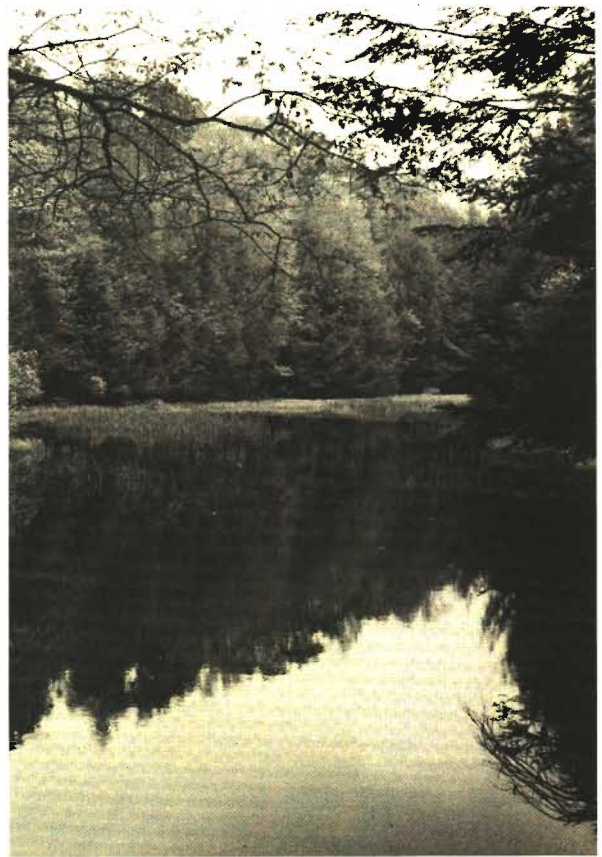


Perhaps in response to these stories, another company soon formed to try to extract a profit from the minerals of Mine Hill. In 1764 Sampson Simpson, Meyer Meyers, and George Trail of New York leased the mining tract owned by the Brownson brothers and launched an even more ambitious operation than the preceding one. Although earlier mining attempts were for silver, the Simpson venture was apparently primarily aimed at lead.

The three New Yorkers hired another goldsmith, Daniel Feuter (no relation to Feuchter), to manage the mining. Feuter employed 33 miners and laborers and one blacksmith. The miners traced the vein outcrops down the mountainside and tunnelled into the hill horizontally along the vein. This horizontal entrance probably corresponds to the middle level of the current network of mine tunnels.

Despite the careful organization of this mining venture, Simpson, Meyers, and Trail were no more successful than the Brownsons had been, and their mine folded within a few years. At least two other companies formed to work the veins, but neither mining attempt lasted long.

Today, it is difficult to say why any serious silver or lead mining venture was ever launched at all. There are galena (lead sulphide) crystals in the main vein, and galena contains up to 2 or 3% silver, but there is so little of the material that it seems inconceivable that it would be worth hiring workmen and sinking a shaft. Perhaps originally there was a more concentrated deposit, which was exhausted by the early mining operations.



The Reservoir

Roxbury's Iron

Although the amount of silver and lead in the vein can never have been very great, there is no question that Mine Hill has considerable quantities of iron ore. Unlike most of the iron ores found in New England, the predominant ore in Mine Hill is iron carbonate (siderite) and not iron oxide (magnetite or limonite). Perhaps that explains why the early miners did not recognize it. In 1820, however, Professor Benjamin Silliman of Yale University mentioned the vein on Mine Hill near New Milford as a source of "spathic iron" a type of ore "much valued in Europe." Then, in 1831 and again in 1837 Charles Upham Shepard, also of Yale University, described the economic potential of the spathic ore in glowing terms. He ended his 1831 article with an outright advertisement for the mine:

Considering, therefore, the inexhaustible supply of the ore and the ease with which it may be raised, — the facilities of wood, water and labor, — and the easy transportation to

market, I am authorized by the present proprietor to submit it to the attention of capitalists, whether a surer investment of capital can be made in our country; or one, which, on the whole, would prove more conducive to our national prosperity, than that above described.

Once again, interest in the minerals of Mine Hill ran high, but in the 70 years following the close of the Simpson mine, the property and mining rights on the hill had changed hands many times. Bitter disputes over the ownership of Mine Hill precluded any serious mining attempts. One set of claimants did begin extracting ore and built a powder house and furnace near the old silver shafts, where the remains of these structures can still be seen today. These claimants were dispossessed soon afterwards, though, and the brevity of their tenure may account for the apparent absence of slag around the remnants of their furnace.

Finally, in 1856 the U. S. circuit court awarded the land to Daniel Stiles, the same proprietor who had authorized Shepard to publicize the iron mines 25 years earlier.

In 1864 a company expressed interest in buying the rights to the mine. The Shepaug Spathic Iron and Steel Company, undoubtedly inspired by Shepard's report, consulted several geology professors at Yale, a firm of New York mining engineers, and the former foreman of a Prussian steelworks concerning the soundness of the mine as an investment. The response was an unqualified endorsement of the project, so in 1865 the company purchased Mine Hill from Daniel Stiles for \$100,000.

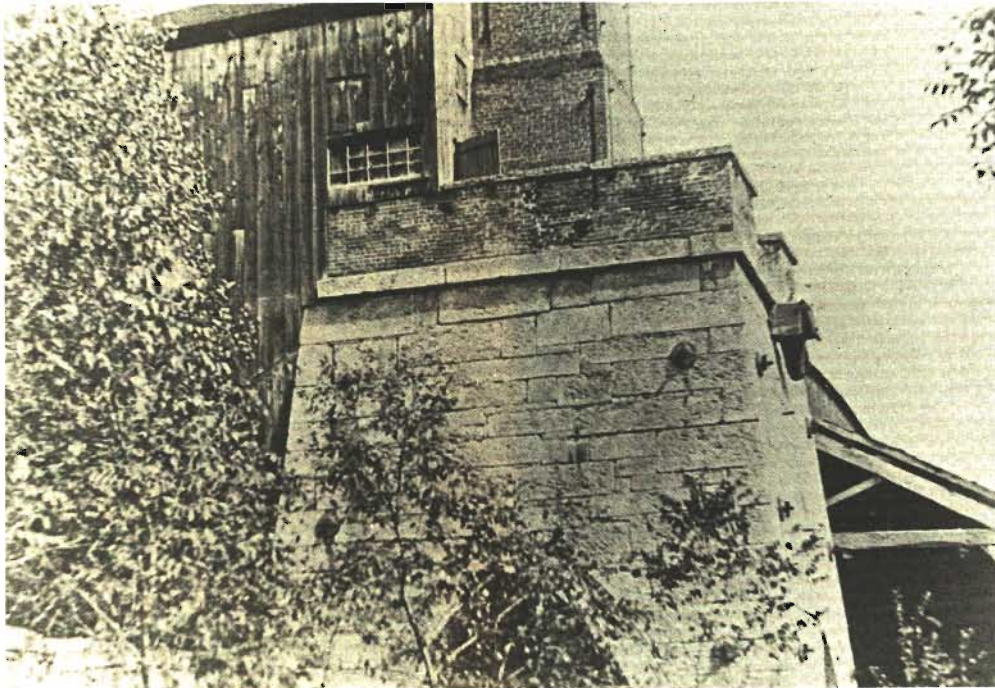
The Shepaug Spathic Iron and Steel Company started with a capital of \$300,000. They immediately hired Henry Kolbe, the same Prussian steelworker who had proclaimed the Mine Hill siderite to be comparable to the German and Austrian steel ores and therefore ideal for the production of cast steel of the best quality. Kolbe was to use his experience gained in Prussia to direct the smelting of the iron ore and the production and processing of steel. The rest of the mining and ironworking operations at Mine Hill was to be managed by Colonel A. L. Hodge, a prominent citizen of Roxbury. A. L. Hodge's responsibilities included overseeing the mining, keeping track of the finances, and keeping the officers of the company informed of the status of their iron business. Because all the experts agreed that a great deal of practical experience was

necessary for the production of steel using the process specially suited to siderite, Shepaug Spathic sent to Germany for six experienced steel puddlers.

Between 1865 and 1868 the firm greatly extended the mine tunnels and constructed a railbed to convey the ore down the hill from the mine. At the base of the hill, near the New Milford road, workmen built two ore roasters, a blast furnace, a steel puddling furnace, and a rolling mill. Long wooden buildings enclosed the working area around these structures. Halfway between the mine and the furnace area, Mineral Spring Brook was dammed to create a reservoir with a reliable water supply. Underground pipes connected the pond to at least three hydrants placed at strategic points in the ironworks.

Some of the structures built during those years still stand in excellent condition; others have been dismantled by subsequent owners or damaged by vandalism and the forces of nature. The physical remains alone would provide valuable clues to the operation of the Roxbury iron works, but by great good fortune, the information from these archaeological resources is complemented by a collection of documents. The books and other records kept by Colonel A. L. Hodge were saved by his descendants, and hold the answers to many questions about the Roxbury ironworks. Colonel Hodge was also a conscientious diarist, and his journals for the years in which the mines were in operation offer many insights into the day-to-day workings of the plant.

Mine History continued on page 30



The blast furnace, ca. 1905

Photo: Joseph West

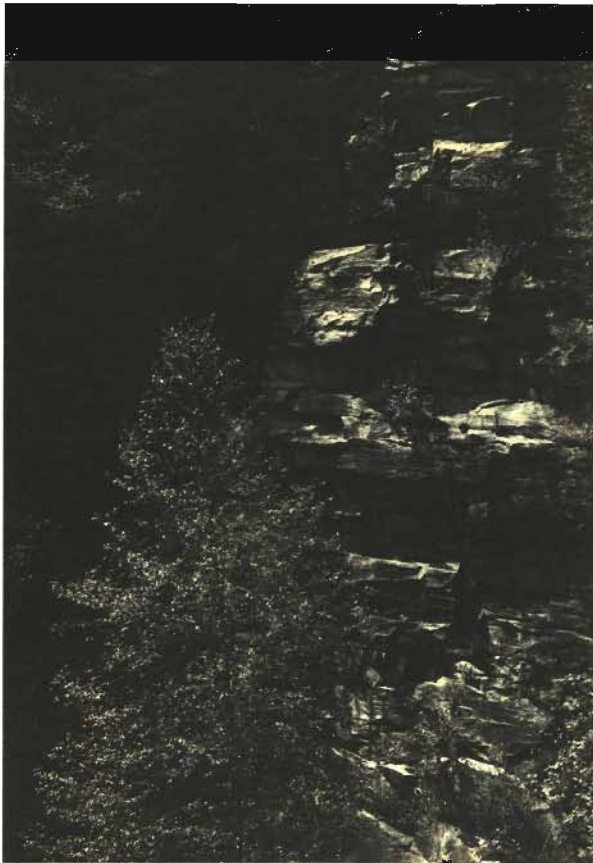
The Quarries

When Benjamin Silliman visited Mine Hill in 1817 he was less impressed by the iron and silver ore than by the stone in which it occurred:

It is . . . singularly perfect in its characters, and it is questionable whether for purposes of architecture the world can produce its superior. . .

. . . The color is of a light, agreeable grey; the finest houses in New Milford have this stone for their door-steps and basements and its natural surfaces, or those, which, at the ends and edges are but slightly modified by the hammer and chisel, are so perfect that nothing finer need be wished for the construction of the handsomest houses in cities. Could it be easily transported to New York, this stone would be a more valuable possession to the proprietor, than the mine of silver or iron.

Over the years, Silliman's prediction has come true, and while the fortunes of the mines rose and fell, the eight quarries on Mine Hill brought their owners a steady income.



Rockside Quarry today

Unfortunately, very few records from the quarrying companies have been found, and even the oldest Roxbury residents remember little about the quarries before the passing of the railroad. It is not clear when quarrying first began, and neither Silliman nor Shepard gave the names of the early quarriers, although both mentioned the fact that Mine Hill's granite gneiss was being used for building. Perhaps at that time, the stone was being quarried on an informal basis by individuals, rather than a formal business, for a later source says that the quarries on Mine Hill were first opened in 1850. The first quarries were almost certainly at the top of the hill. Ox carts carried the quarried rocks to Roxbury and New Milford, but because transport was so difficult, it is unlikely that the stone was used outside the immediate area.

Then, on January 1, 1872, the Shepaug Valley Railroad opened with a station in Chalybes. The line ran along the foot of Mine Hill, where in some places the old railroad grade is still discernable today. Now it was possible to transport the stone further away, even as far as New York. In 1890, a new quarry was opened at the bottom of the hill, much closer to the railroad than the older quarries. Nine years later John Eckerson and Louis Beck of New York, Charles Coit of Litchfield, and Charles Hodge of Roxbury formed the Mine Hill Quarry Company to work the Rockside Quarry, as the quarry at the foot of the hill was called. There is no record of who ran any of the quarries before the Mine Hill Quarry Company was formed, and unfortunately, aside from the minutes of the first meeting of directors and a single stock certificate, no records from the Mine Hill Quarry Company have been found either. Still, some of the outlines of the operation can be pieced together from old photographs and the physical traces of the quarrying.

Rockside Quarry is located on the eastern side of Mine Hill Preserve. The Mine Hill Quarry Company ran a private rail line to a loading dock on the Shepaug Valley line. Although the railroad passed the quarry about a hundred meters to the east, the loading dock is situated north, considerably further from the quarry than was the railroad. Perhaps the quarry company could not run their rail line east because they did not own that property, which is excellent farmland. Photographs taken 1905 by Joseph West of Washington, Connecticut, show the rails and cars for transporting the stone to the main railroad. Many of the blocks still littering the quarry show drill cores where the stone was split against the grain, and deep circular holes in the ground mark the places where derricks were set to bring the stone down from the cliff face and move it to the rail line.



Rockside Quarry, ca. 1905

Photo: Joseph West

Access to the railroad was also built for the upper quarries. Twin ramps ran from the quarries to the foot of Mine Hill. A spur line connected the railroad to another loading dock located at the bottom of the ramps, just south of the furnace area. A winching system joined cars on both ramps, and the weight of the laden cars coming downhill would pull the empty cars on the other ramp back up to the quarry.

After the railroad opened, Mine Hill Granite Gneiss was used in New York as well as Connecticut. Churches in Litchfield, New Britain, Watertown, and Waterbury, the buttresses of the 59th Street Bridge in New York, and a railroad approach to Grand Central Station all were built with Mine Hill stone.

Like the iron mining of the 1860's and 1870's, the quarrying supported the little town of Chalybes. The town gradually came to be called Roxbury Station after the railroad came through and the ironworks closed down. Some of the quarry workers lived there with their families, others were single men who boarded at private homes or stayed at the hotel. Some quarry workers also lived in Roxbury Center and Washington and went to and from work by way of a suspension bridge that spanned the Shepaug across from Rockside Quarry. Many of the quarry workers were Italian or Irish immigrants. Several workers also had ties to other

quarries in New England: William McKay, the last manager of the upper quarries, came to Roxbury from the Stony Creek Quarries near the Connecticut coast; and Frank Collins, the English blacksmith who made and repaired parts for the machines and tools used in quarrying, left his shop by the old iron mine entrance each winter to work at the Stony Creek Quarries.

The upper quarry closed down around 1905, and when the Shepaug Valley Railroad stopped operating in 1935, Rockside Quarry also closed. Without the railroad and quarries, Chalybes slowly lost its population and commerce to the larger industrial centers of New England.

Then, in 1952, Charles Showalter obtained permission from William and Adelaide Matthews (the descendants of A. L. Hodge and former owners of Mine Hill) to cut and sell stone in the lower quarry. Soon afterwards, he moved his operation to the upper quarries, where the stone is easier to work. He and his son worked the upper quarries until 1961, when Gino Perone, a stone mason from Southbury, took over the business of salvaging building stone from the Mine Hill quarries. Mr. Perone and his part time assistant sell the stone they cut for hearths and door steps in houses near Roxbury and New Milford, much as the first quarriers on Mine Hill must have done.

In the spring of 1867, the plant was ready to begin processing the ore into cast iron. Unfortunately, some problems arose during the initial operation of the blast furnace, and the construction of the machinery to refine the iron into steel also encountered difficulties. After having invested so heavily in the construction of the plant, the Shepaug Spathic Iron and Steel Company did not have enough capital left to tide it over early delays in production and necessary repairs to the machinery. Early in 1868, therefore, the firm applied to the state legislature for permission to raise additional capital by selling more stock.

When it received permission to increase its capital investment to \$1,000,000 the company reorganized and changed its name. The American Silver Steel Company moved the steel making facilities to Bridgeport and limited work at Mine Hill to the mining and smelting of ore. For a few years everything went well, but in 1872 the firm found it necessary to reorganize again.

The new company, called the Shepaug Iron Company, soon abandoned the mining and processing of ore completely and simply sold off ore and iron that had been produced before 1872. Although the Shepaug Iron Company stayed in existence for years, they do not seem to have done any further work at Mine Hill.

Through all the changes in company structure and directorship, A. L. Hodge had remained the onsite manager of the mines and ironworks. Finally in 1894, he bought Mine Hill from the Shepaug Iron Company. Under his ownership the mines were not worked for ore again, and as the years passed, maples, ash, and hemlocks reclaimed the land once more.



Brickwork in the furnace arch

From Ore to Steel: The Siderite of Mine Hill

Most iron ore is in the form of an iron oxide. In order to obtain useful iron from such a source, one must heat the ore in the presence of carbon. The oxygen in the iron ore then combines with the carbon, leaving behind nearly pure iron. If this heated iron is hammered vigorously, the impurities from the ore and the carbon fuel are mostly expelled. Although the machines and methods for smelting iron have changed greatly since man first began using the metal, the fundamental principle of heating the ore in the presence of carbon remains the same.

The properties of iron vary greatly, depending on the amount of carbon and other elements mixed in with the metal. If there is less than 0.3% carbon and from

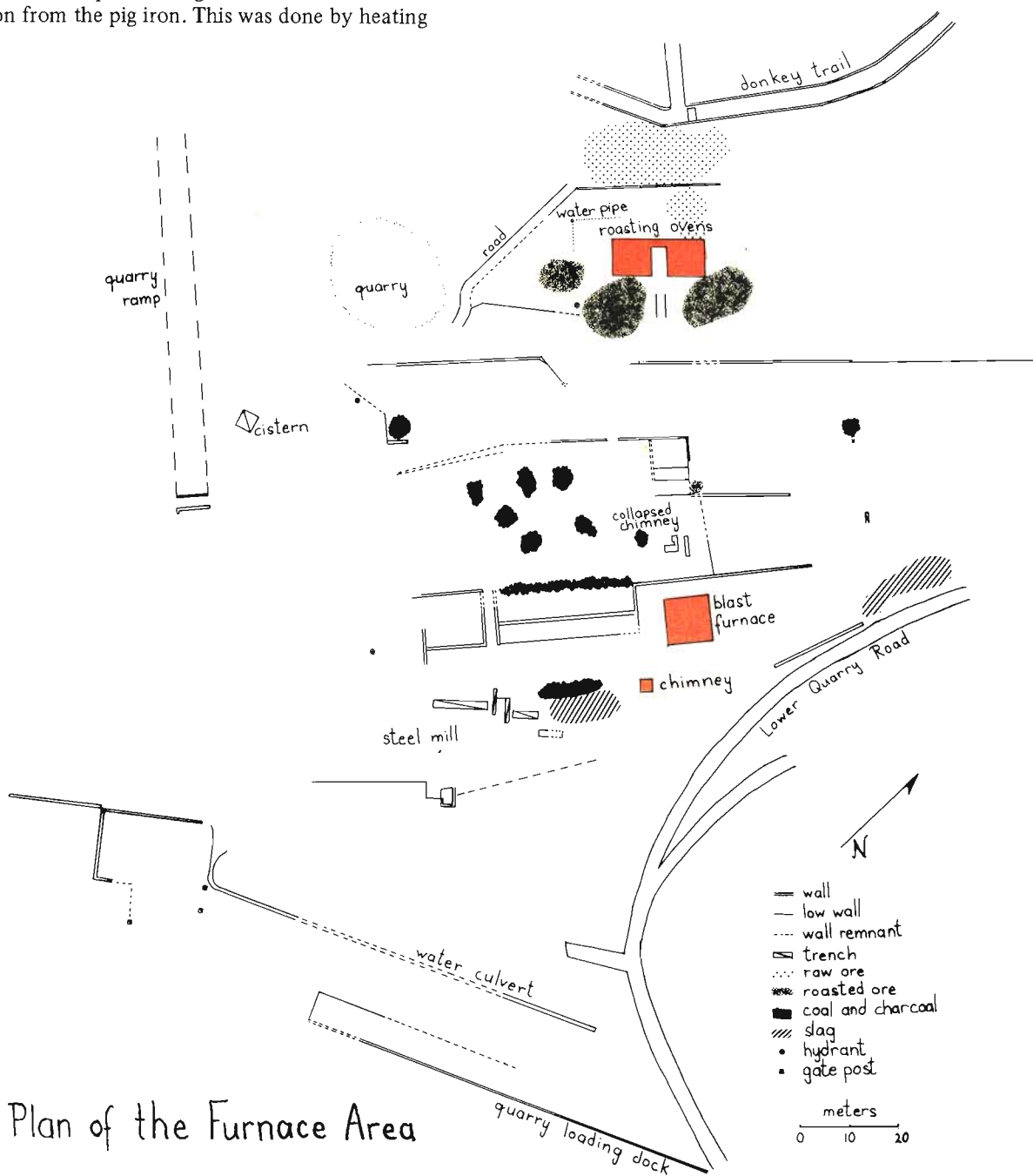
1 to 2% slag mixed in, the metal has a very high melting point and a great deal of strength under tension. This form of iron is referred to as *wrought iron*. If the iron contains more than 1.8% carbon, it has a much lower melting point and great strength under pressure, but little under tension. This type of iron is called *cast iron*, because it is shaped by being melted to a fluid and then cast in molds. Iron which contains intermediate amounts of carbon in chemical combination and little or no slag is called *steel*. The properties of steel vary greatly depending on the amount of carbon and other elements it is alloyed with. The most valuable properties of steel are its superior hardness and resistance to weathering.

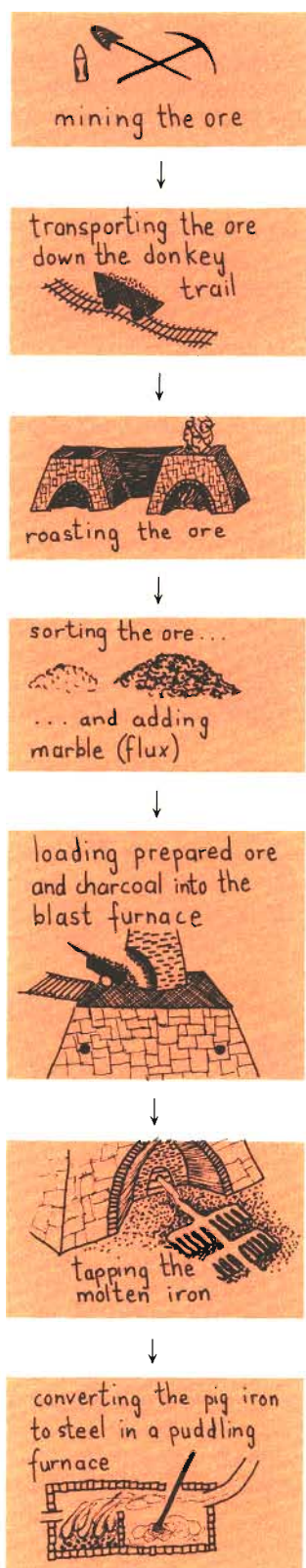
19th Century Methods of Steelmaking

The normal method of iron production in the 19th century was to first heat the ore with charcoal or coked coal in large blast furnaces. The molten metal these furnaces produced had a high concentration of carbon from the charcoal or coke, that is, it was suitable for making cast iron. This iron was also known as *pig iron*, because the molten metal was removed from the furnace by being allowed to run into channels dug into the sand in front of the furnace. The main channel was likened to a sow, the side channels to pigs.

The next step in making steel was to remove the carbon from the pig iron. This was done by heating

the cast iron in a refractory oven, so the metal was not in contact with the fuel. The carbon in the metal would burn, that is, it would combine with the oxygen in the air being blown over it, and would escape as carbon monoxide or carbon dioxide. When most of the carbon had burned, the iron would be removed from the furnace and hammered out; the result was wrought iron. Because the iron was constantly stirred while it was in the furnace in order to expose as much of the carbon as possible to the air, this type of furnace was called a *puddling furnace*.





Finally, in order to make steel, a limited amount of carbon had to be re-introduced to the metal. There were two processes commonly used to accomplish this in the first half of the 19th century. One involved packing the wrought iron with charcoal in a sealed container and heating it for a long time — up to two weeks. This process would introduce carbon to the outer edge of the piece of iron, producing what was essentially steel-coated wrought iron. This process was called *cementation*, and the product was known as *blister steel*, because the surface of the iron acquired a dark, blistered appearance. In the second method higher quality steel was produced by further processing of the blister steel. First, shear steel (blister steel which had been broken up, rewelded, and recemented) and flux were placed in a sealed container. This container, the crucible, was then heated beyond the melting point of steel, so the carbon in the skin of the shear steel diffused throughout the metal. In this method any impurities in the steel would combine with the flux, rise to the top of the crucible, and be removed as slag. This resulted in a steel of uniform consistency called *crucible steel*.

Most iron and steel is manufactured from iron oxide ores. The type of iron ore at Mine Hill is not a simple iron oxide, but an iron carbonate; that is, the iron is combined with carbon as well as with oxygen. This type of mineral, siderite, is not uncommon, but it is rarely found in large vein deposits like the one at Mine Hill. Similar siderite veins were, however, mined in Austria and Prussia in the 18th and 19th centuries. The ironworks in both those locations produced steel in an unusual manner.

The siderite steel works in Prussia and Styria essentially avoided the final step in the normal steel making procedure. They produced steel by the superficially simple expedient of stopping the puddling process before all the carbon was driven off. Despite the fact that this method relied heavily on the intuition and “feel” of the workmen, for there was no way to measure the carbon content of the iron in the puddling furnace, the German and Austrian steel were considered to be of excellent quality. The great advantage of this shortened process was not only that it saved an expensive step, but that it could handle much larger quantities of metal than either the cementation or the crucible method. It is therefore not particularly surprising that much of Silliman and Shepard’s enthusiasm about the Roxbury iron stemmed from their belief that this type of ore lent itself to being converted into steel “directly from the pig,” like its European counterpart. In fact, however, the same steel-making methods work equally well on both iron carbonate and iron oxide ores.

The Shepaug Spathic Iron and Steel Company seems to have placed a great deal of faith in the pronouncements of professors Silliman and Shepard. The company launched a very ambitious mining and steelmaking operation that relied on the assumption that they would duplicate the success of the Prussian and Austrian steel-works.

Mining the Ore

The first requirement for making steel at Mine Hill was clearly the production of ore. Local tradition claims that experienced miners were hired from England; the company's records neither confirm nor deny this claim. Mining through the hard Mine Hill Granite Gneiss was a slow business. The miners were paid around \$11 per linear foot of tunnel and were reimbursed for their powder and candles. They would use hand drills to drill into the rock, fill the drill holes with powder, and blast the rock loose. By these slow, backbreaking methods about 850 meters of known tunnels were excavated on Mine Hill.

Once the tunnels had been opened, the ore could be removed from the veins. All the ore was loaded into ore carts. These carts moved on 24-inch gauge rails, which ran from the entrance of the lowest tunnel downhill to the furnace area. The empty ore carts were drawn back uphill by donkeys, and to this day the roadbed on which the carts ran is called the donkey path. The first load of iron ore came down from the mines on the 23rd of January, 1867.

Processing the Ore

The first step in the processing of siderite was to heat the ore in one of the two large ovens located west of the main blast furnace. This "pre-roasting" drove off some of the carbon and sulphur contained in the Mine Hill ore. The large amounts of carbon contained in siderite might otherwise have caused explosions in the blast furnace, and even small traces of sulphur render iron and steel crumbly and unworkable when hot. The resulting roasted ore was mainly iron oxides and quartz. On January 30th, 1867 A. L. Hodge wrote in his diary: "today filled the East Oven in the roast furnace the first time."

Next, the ore was sorted. Roasting the siderite into iron oxide made it brittle and easy to hand separate from the unwanted quartz. Remains from the sorting operations can still be seen in two piles of roasted ore near the roasting ovens. One contains a normal amount of roasted siderite, but the other contains little but quartz. Once sorted, the ore was moved down the charging ramp to the furnace. The charging ramp was an enclosed platform reaching from the roasting ovens

to the top of the blast furnace. On its way to the furnace, the ore was crushed and mixed with pieces of marble. A pile of marble blocks ready to be added can be seen about halfway down the old charging platform.

Now the ore was ready for smelting. Workmen charged alternate loads of prepared ore and charcoal into the top of the blast furnace. The circular sieve which now lies at the base of the furnace may have been used to sort the charcoal.

As the ore and charcoal worked their way down the furnace, the heat from the burning charcoal would drive off the moisture and gases from the ore. Further down in the furnace, in the intense heat generated by the blast-fanned burning charcoal, the carbon in the charcoal would combine with the oxygen in the roasted siderite and escape as carbon monoxide and carbon



Abandoned ore cart

dioxide. Only the now molten iron and some impurities such as quartz remained behind. The impurities would combine with the calcium from the marble that had been mixed in with the ore. The resulting material, called *slag*, was lighter than the iron and floated on top of the molten metal glowing in the crucible of the furnace.

When the crucible became full, the slag was drawn off from the top through a hole in the side of the furnace. The iron was tapped through a hole lower down in the side of the hearth and allowed to run into channels in the sand casting bed, where it cooled into iron pigs. The slag may have been run off on either the northeast or southwest side of the furnace, and the iron was probably tapped on the northeast side.

The brick chimney located just southeast of the furnace was part of the blowing engine that provided the blast. A constant stream of air was necessary to maintain the roaring fire and was forced into the base of the furnace through four pipes called *tuyeres*.

Some of the pig iron may have been sold without further processing, but the company planned to convert most of it to steel. Presumably, Henry Kolbe (the Prussian supervisor) and the specially imported German workmen employed the techniques and machinery used in Prussia and Austria, but the structures and machines of the steel-making process have been dismantled, leaving only the foundations. William Fairbairn in the book *Iron, its History, Properties, and Processes of Manufacture*, published in 1865, describes the German process of making steel as follows:

In Styria, Carinthia, Thuringia, and other parts of the Continent, steel is produced from crude iron by the decarburising effect of a blast in a furnace similar to a refinery. The pigs are melted by charcoal, and a strong blast allowed to play over the molten surface. The converter stirs up the iron to bring fresh portions under the action of the blast, until he judges, by the consolidation of the mass and the colour of the flame, that the process has been carried far enough.

Perhaps an archaeological investigation could cast more light on the milling machinery and how exactly Henry Kolbe and his German workmen tried to make steel in Roxbury.

Fuel

Pre-roasting the ore, smelting, and puddling the pig iron all demanded large quantities of charcoal. Northeast of the reservoir shallow circular ditches mark the location of old charcoal kilns in which Mine Hill's lumber was converted to charcoal. However, the hill did not have enough trees to run the furnaces long. An acre of land could supply enough fuel to make about 6 to 7 tons of pig iron, on the average. The blast furnace at Mine Hill produced about 100 tons a month of pig iron when it was running well. Thus, the blast furnace alone could have consumed up to 190 acres worth of timber each year.

The Shepaug Spathic Iron and Steel Company looked to the landowners of Roxbury to supply them with fuel. The production of charcoal probably was the main form of employment the mining venture offered to Roxbury natives. Other jobs associated

with the mine required skills the local farmers did not have. Some Roxbury citizens simply sold their standing timber to the company. Others operated charcoal kilns at Flagg Swamp and other locations and delivered finished charcoal to Mine Hill. The old charcoal piles, now covered with trees and leaf litter, are scattered throughout the furnace area.

The Demise of Roxbury's Iron

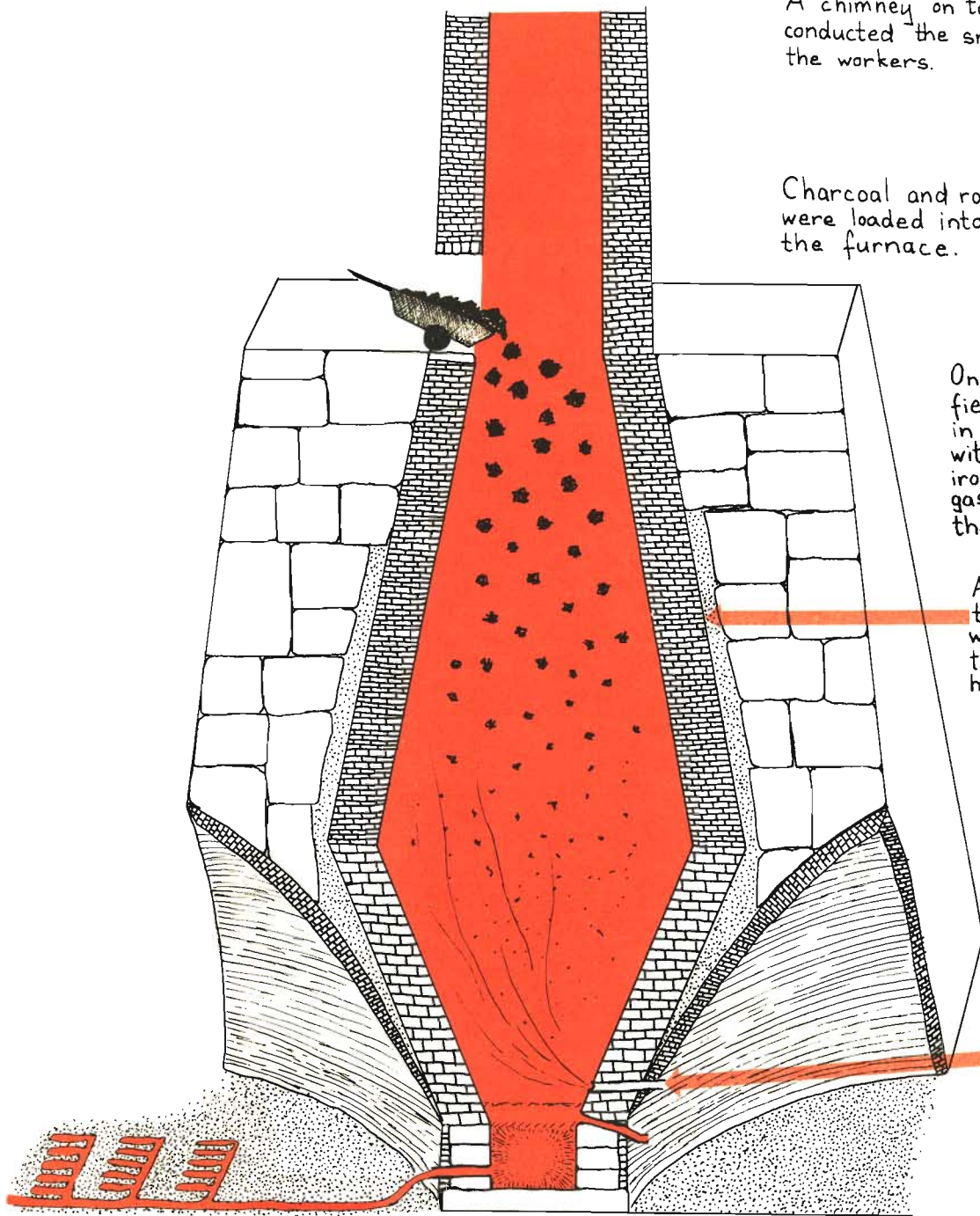
Despite the elaborate planning and heavy initial investment, production at the Shepaug Spathic Iron and Steel Company's Roxbury works apparently did not go as planned. Shortly after the first run of the puddling furnaces, the German workmen were dismissed. Kolbe left soon afterwards. A little later, in conjunction with the reorganization of the business by the American Silver Steel Company, the steel making machinery was moved to the new plant in Bridgeport.

A. L. Hodge does not offer any reason for these changes in his diary. Possibly, the steel making did not work as well as expected, or perhaps the decision to abandon on-site steel production was based on other factors. Maybe further research can provide the answer.

After the steelworks were moved to the Bridgeport plant, the smelting of cast iron in Roxbury proceeded uneventfully for a few years. Oxcarts carried the pig iron over the hill to New Milford; from there it travelled by rail to Bridgeport. The Bridgeport plant manufactured steel in one of the first American Siemens-Martin furnaces. This type of furnace was the forerunner of the open hearth process, which is commonly used in modern steel production.

In the fall of 1871, the company decided to convert the blast furnace on Mine Hill from cold to hot blast. In furnaces operating with hot blasts, the air stream fanning the combustion inside the furnace was preheated. Often, waste gases from the furnace itself provided the heat for the blast. Preheating the blast usually saved fuel and raised the output of the furnace because the hot air did not use up any of the energy generated by the combustion in the furnace.

Normally, the conversion from cold to hot blast was a simple operation, and many furnaces made the change very successfully. At Mine Hill however, the change seems to have damaged the furnace in some manner. Instead of rising, the output of pig iron fell, and the furnace began to malfunction. Within a few months, the furnace closed down for good.



A chimney on top of the furnace conducted the smoke away from the workers.

Charcoal and roasted siderite were loaded into the top of the furnace.

On the way down the fiery stack, the carbon in the charcoal combined with the oxygen in the iron ore and escaped as gas (CO_2 and CO), leaving the iron behind.

A layer of sand between the stack and the stonework allowed the stack to expand in the intense heat.

Arches in the base of the furnace provided access to the crucible.

The hotter parts of the furnace were lined with heat resistant yellow fire brick.

A continuous blast of air blown into the furnace through the tuyere pipes kept the fire roaring.

Molten iron collected in the crucible at the base of the furnace. The lighter impurities in the ore floated on top, forming slag.

The iron was tapped from the side of the furnace and allowed to run into channels dug in the sand floor. Here it cooled to form the iron bars known as pigs.

Cross-section of a Blast Furnace

Epilogue

Many people have wondered why, after such high expectations, the iron mining venture at Mine Hill proved such a failure. In part, the operation suffered from technological problems. The very first run of the furnace resulted in a ruined hearth, when the iron solidified into a “salamander” at the bottom of the crucible. The hearth itself had an experimental design; it was constructed in the form of an ellipse rather than the traditional circle. However, the oval design turned out to be inefficient, and was only installed in four furnaces in the United States. Perhaps the steel produced by the German method of puddling was not as good as had been anticipated, and after the conversion to hot blast, the furnace clearly did not function well. Also, contrary to all expectations, the main iron vein narrows out with depth. Yet a great deal of ore remains in the hill, and none of these technological problems should have been insurmountable. In fact, after the unsuccessful first run of the furnace, the damaged hearth was quickly replaced, and by all reports the steel production in the Bridgeport plant was highly successful.

It may be more helpful to look at the iron venture in a broader context. Seen from the perspective of events in the U. S. iron and steel industry from 1865 to 1872, the operation at Roxbury was some ten years out of date.

At a time when most new blast furnaces were running on coal or coke, the Roxbury furnace was built to burn

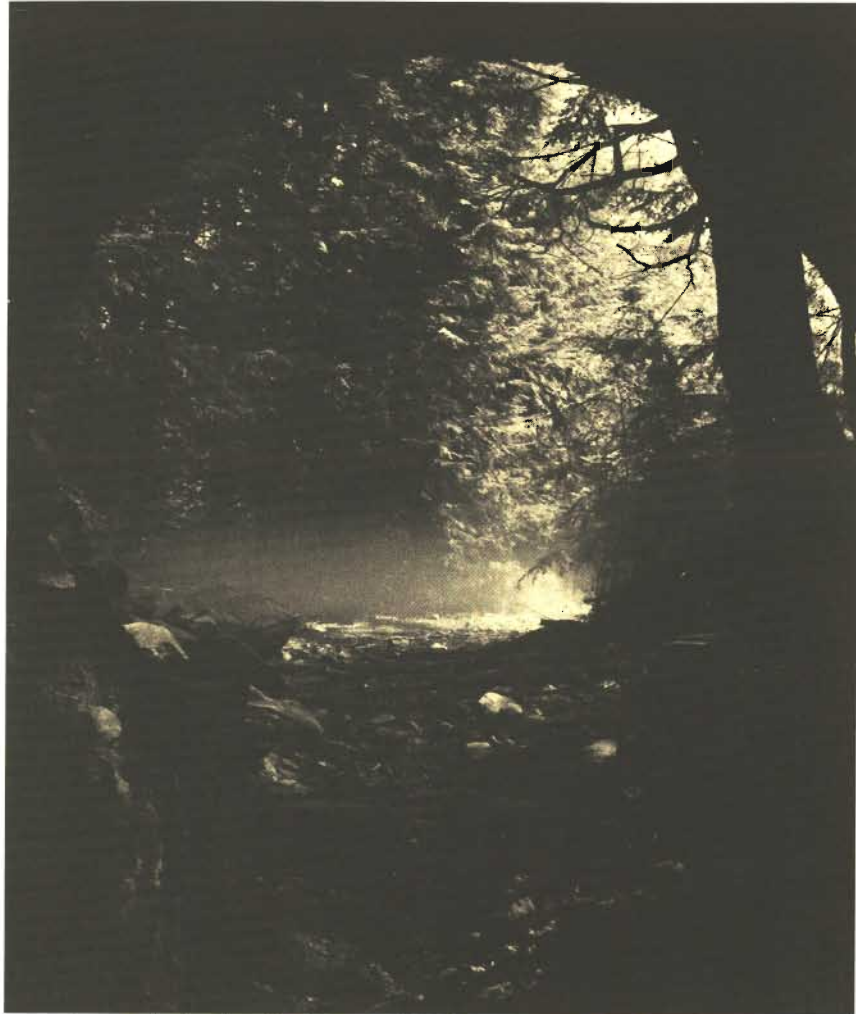
charcoal. The coal and coke burning furnaces had capacities ten or more times greater than that of the Mine Hill furnace.

Even more important, two new steelmaking processes were being introduced which solved the production bottleneck in making high quality steel much more effectively than the German puddling technique. These were the Bessamer/Kelly process and the open hearth process used at the American Silver Steel Company’s Bridgeport plant.

Also, the absence of rail transportation from Mine Hill must have reduced any competitive advantage of the venture from the very start. When the railroad finally did come to Roxbury, the company had already been through two bankruptcies, and the country was entering the depression of 1873. Also, in that time the great iron deposits in upper Michigan and Minnesota were being opened up, next to which the Roxbury siderite deposit was small potatoes indeed. Perhaps, if the land title had not been contested so fiercely and if the iron mining had begun a decade earlier, Mine Hill might have played a more significant role in the history of the American iron and steel industry. Instead, Mine Hill remains a monument to the many small rural industries of New England, which gave rise and gave way to the technological advances of the late 19th century.



Photo: Greg Yovan



Layer of mist forming just outside the entrance to the mine tunnel.

