THE ECONOMIC GEOLOGY OF THE MID-HUDSON VALLEY REGION

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Introduction

A diverse terrain endowed with a wide variety of available mineral resources, sustained demand for these resources and economical means of transportation have combined to foster a dynamic mineral industry in the Mid-Hudson Valley region which has prospered since the early 19th century. Production valued at about 100 million dollars in 1965 accounted for approximately one-third of the State's entire mineral economy. Of greater significance is the fact that the Mid-Hudson Valley's mineral production is concentrated in less than one percent of New York State's total land area (47,944 square miles). The principal products are crushed stone aggregate, building stone, lightweight aggregate, sand and gravel, portland cement, natural cement and brick — materials all necessary to building and highway construction.

Systematic geologic studies of the nature and use of rock raw materials have produced revolutionary changes in the economics of industrial mineral production in the Hudson Valley during the last decade. The result has been an increase of crushed stone reserves by a factor of 3 to 5, cement reserves by a factor of 5 to 10 and lightweight aggregate reserves from nothing to well over a billion tons. This represents another example of taking what is available and utilizing it all, by separation or by blending, for the most useful purpose. The economic rock section ranges in age from Cambrian to Middle Devonian (Tables B1 and B2).

Trip B is specifically planned to allow participants the opportunity to examine in a day's time the greatest variety of rock raw materials and mineral commodities typical of the Mid-Hudson Valley. The following U.S. Geological Survey 7.5-minute topographic quadrangles cover the route of the trip in order: Newburgh, Wappingers Falls, Poughkeepsie, Hyde Park, Kingston East, Kingston West, Rosendale and Clintondale.

The only publication dealing in depth with the economic geology of the Hudson Valley region and available on request from the Hudson River Valley Commission is as follows:

Broughton, John G., Davis, James, F., Johnson, John H., The Hudson: Mineral Resources: p. v, 103, 3 Pl., 12 Figs.; A report on the geology and mineral resources of the middle and lower Hudson Valley; State of New York, Hudson River Valley Commission, Oct., 1966.

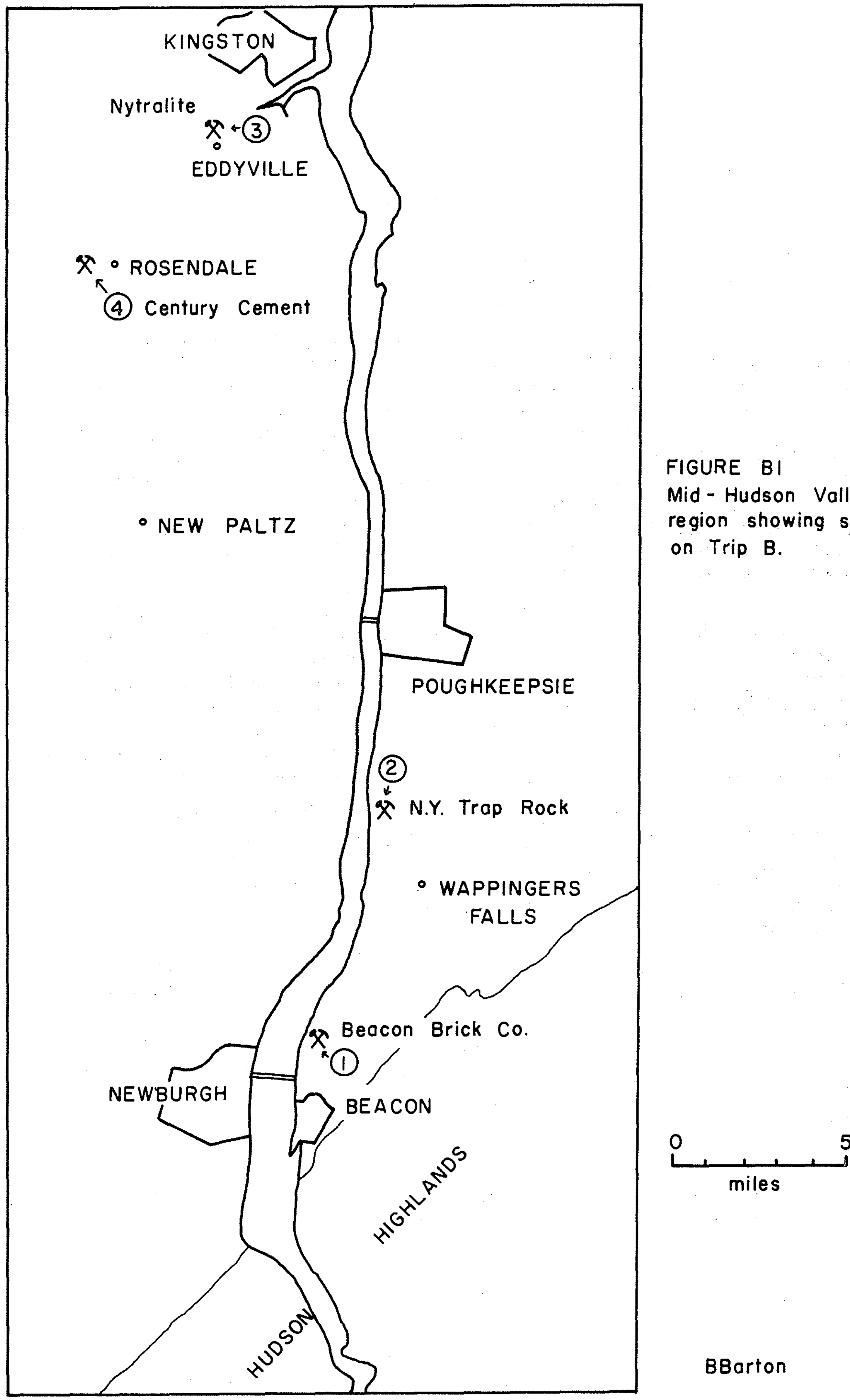


FIGURE B1
Mid - Hudson Valley region showing stops on Trip B.

BBarton

ROAD LOG TRIP B

Co-Leaders: John H. Johnsen and Simon Schaffel

Cumulative Mileage	Distance between points	
		Time: 8:30 A.M.
0.0		Leave Holiday Inn and turn east (left) on Route 17K. Precambrian Highlands of the Hudson ahead and to south (right).
0.3	0.3	Turn north (left) for Interstate 84 at traffic light.
0.8	0.5	Entrance to Interstate 84. Turn east (right).
1.0	0.2	Road cut in Upper Normanskill shales (brachiopod facies) of Ordovician (Trenton) age.
2.8	1.8	Road cut in fault block of Cambrian-Ordovician dolostones of the Stockbridge Group.
3.7	0.9	Proceed east across the Newburgh-Beacon Bridge. Note the Hudson Highlands on right (southeast to south). The two principal ridges reaching to the river's edge (Breakneck Ridge on the east and Storm King Mountain on the west) mark the northwestern front of the Precambrian crystalline Hudson Highlands. The northeast-southwest boundary with the Paleozoics of the Great Valley is marked by a moderately high angle reverse fault dipping toward the southeast. The Storm King Formation (hornblende granite, hornblende granitic gneiss and leucogranite) is the most resistant of the Highlands lithologic units and forms the two ridges. The Hudson River forms a gap separating these ridges which is commonly referred to as the "Northern Gateway to the Hudson Gorge or Hudson Highlands". In the more than 150 miles between Green Island Dam at Troy and New York Harbor, the Hudson River is an arm of the sea for it experiences the daily rise and fall of the oceanic tides. Traces of salt are detectable in the estuary north nearly to Poughkeepsie, but normal marine salinity extends only to the Northern Gateway. The Catskill Aqueduct of the New York City Water Supply system passes from Storm King Mountain across the river into Breakneck Ridge (Figure B2). The pressure tunnel through solid rock more than 1,000 feet below the Hudson is one of the classic engineering geologic projects of all time. Construction of a pumped-power generating plant using a storage basin on top of Storm King Mountain has been proposed by the Consolidated Edison Company of New York; this project has been the subject of substantial publicity recently. The Beacon Brick Corporation (Stop 1) can be seen one mile north (left) on the east bank at Brockway.
5.2	1.5	Toll booth.

Cumulative Mileage	Distance between points	
5.5	0.3	Exit Interstate 84 on right, proceed up slight grade and turn north (left) on Route 9D towards Wappingers Falls.
6.3	0.8	Turn west (left) on Brockway Road opposite Gulf gasoline station. Sign indicates entrance to Denning Point Brick Works (now Beacon Brick Corporation).
6.8	0.5	Turn north (right) on unimproved road to shale quarry.
7.0	0.2	Time: 8:55 A.M. STOP 1 (45 minutes):

STOP 1: Shale quarry and clay pit of the Beacon Brick Corporation

Exposed in the quarry are grayish-black, red and green slaty shales of the Normanskill Formation (Table B1) which are blended with clay to manufacture brick. Note slaty cleavage parallel to bedding.

Hudson Valley brick is produced by either the "soft mud" or "stiff mud" process. "Soft mud" brick is made from clay to which an excess of water has been added to secure plasticity. The soft mud is placed in wooden molds which have been dusted with sand and the clay is allowed to dry before firing. Extreme care must be exercised to avoid drying cracks and shrinkage. The "stiff mud" process is used most frequently by the modern brick industry. Highly plastic clays are undesirable for this process so that ground shale is usually added to the mix. The stiffer clay or clay-shale mix is extruded through a rectangular die and bricks are cut off by taut wires. These unfired bricks, being stiffer, can be handled with less danger of deformation.

Proceed to clay pit. Exposed in the pit is clay that represents fine mud deposited in one of many meltwater lakes that occupied the Hudson Valley during the retreat of the ice in the Late Pleistocene. The clay is normally bluish gray but it may be yellow when weathered due to the oxidation or iron. Thin beds and lenses of sand are frequently interstratified with the clay. The thickness of the clay is variable in this region, but it may exceed 200 feet in some localities. This glacial clay is well adapted to brick manufacture. It is plastic and usually has sufficiently large proportions of fluxing agents - such as alkalies, iron, lime and magnesia - to permit vitrification at relatively low temperatures. The finished product is generally red or pink in color.

The Beacon Brick Corporation uses a clay-shale mix to make extruded wire-cut brick. Firing takes place in a tunnel kiln having a capacity of 100,000 bricks per day. The chief market area is New York City with transportation by barge.

Lightweight aggregate is manufactured from shale or clay by heating these materials until they expand to form porous, scoriaceous material by the evolution of gas bubbles at elevated temperatures (see Stop 3). The Normanskill Shale is considered a potential source of lightweight aggregate raw material; however, pilot tests of the shale from this area yielded an unsatisfactory product because of the lack of compositional uniformity and the large amount of micro- and mega-structural diversity. The slaty cleavage caused slivery rather than equidimensional fragments on crushing which produced a pleated appearance on bloating similar to expanded vermiculite. Although this structure does not necessarily result in an aggregate of low strength, it does make a less attractive aggregate in terms of con-

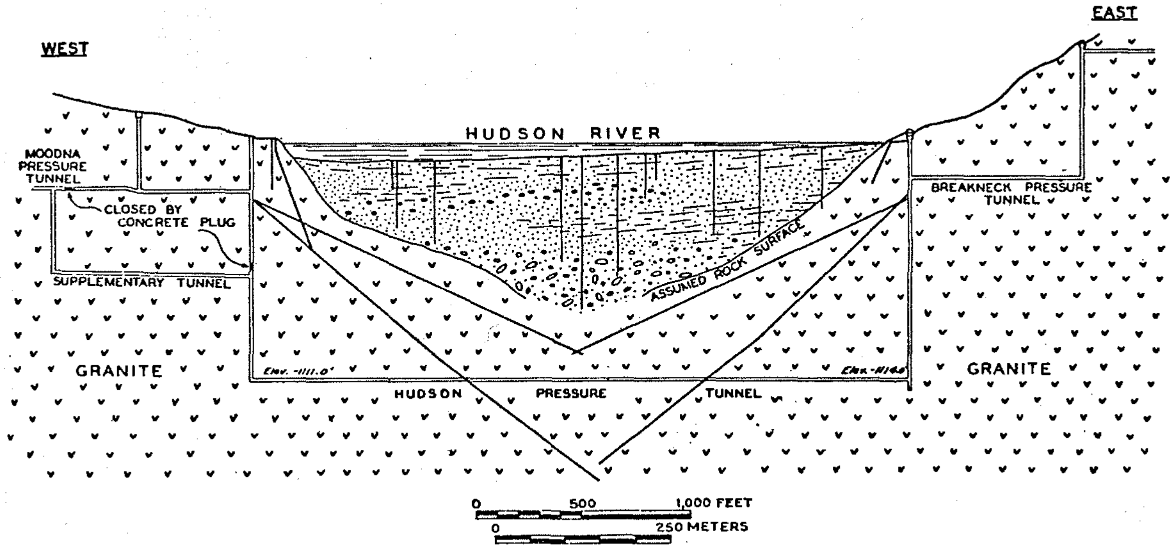


Figure B2. Geologic section across the Hudson River at Storm King, based on exploratory borings for the Catskill Aqueduct. From XVI International Geological Congress, Guidebook 9, p. 108, 1933.

sumer acceptance.

So far as is known, there has been no attempt to produce lightweight aggregate from Hudson Valley clay.

Cumulative Mileage	Distance between points	
		Time 9:40 A.M.
7.0		Leave shale quarry and retrace route via Brockway Road to Route 9D.
7.8	0.8	Turn north (left) on Route 9D.
12.0	4.2	Hughsonville.
12.8	0.8	Entering Wappingers Falls.
13.3	0.5	Leave Route 9D by turning east (right) on East Main Street at traffic light.
13.6	0.3	Follow directions to Poughkeepsie by bearing left (north) on Route 9 at traffic light.
14.4	0.8	Crossing Wappingers Lake.
15.0	0.6	Traffic light at intersection of Routes 9 and 9D. Continue north on Route 9 to next traffic light.
15.8	0.8	Turn west (left) at traffic light onto Old Post Road (opposite Texaco and Gulf gasoline stations).
16.0	0.2	Turn south (left) on Sheafe Road at bottom of hill. For the next half mile glacio-fluvial sands and gravels exhibiting ice contact features are visible on right.
16.7	0.7	Bear right on road leading down to the New York Trap Rock Corporation - Clinton Point Plant.
17.7	1.0	Cross bridge over N.Y. Central Railroad and follow signs to Plant Office.
17.9	0.2	Storage silos capped by screen house on left. The crushed stone is separated here into sizes ranging from 2.5 inches to stone screenings (material passing a 1/4-inch screen).
		Time: 10:10 A.M.
18.0	0.1	STOP 2: (One hour):

STOP 2: New York Trap Rock Corporation, Clinton Point Quarry

Plant Office and loading dock. Hard hats will be loaned to those participants not bringing them. The borrowed hats will be returned at Nytralite Aggregates, Inc. (Stop 3).

Two belts of dolostone suitable for crushed stone aggregate occur along the Hudson River in the lower reach of the Mid-Hudson Valley (see Lower Hudson Sheet, Geologic Map of New York State, 1961). The southernmost of these two belts follows the northern margin of the Hudson Highlands north-northeast from the vicinity of Beacon to the eastern portion of Dutchess County where it veers more northerly, eventually crossing into northern Connecticut and Massachusetts; the other belt begins southwest of Newburgh and also trends north by northeast to cross the Hudson at New Hamburg (situated at the mouth of Wappinger Creek) where it occurs in two distinct bands over a short distance and continues in the same north-northeasterly direction to the upper part of Dutchess County.

The rocks take their name, Stockbridge Group, from Stockbridge, Massachusetts, where the northeastern extension of the southernmost belt has been metamorphosed to marble. In the field trip area, the carbonates are unaffected by metamorphism and frequently are referred to as the Wappinger Group, a name well established in the literature. The Stockbridge succession includes carbonate rocks that are Late Cambrian to Early Ordovician in age although that part of the succession in the vicinity of the Hudson River may be all Cambrian. The sequence includes a series of dense to finely crystalline, gray dolomitic rocks ranging from dolomitic limestone to dolostone which collectively are calcitic dolostones.

At Clinton Point, the rock is dolostone, with a magnesium carbonate content of 38.16 percent. Here the New York Trap Rock Corporation, a subsidiary of the Lone Star Cement Corporation, produces every conceiveable size of stone ranging from riprap to stone sand and screenings.

The quarry opening is effectively blocked from river view by a 500-foot wide buffer zone or "mercy strip". The dolostone reportedly extends to considerable depth and a portion of the quarry floor is now 60 feet below the level of the Hudson River. Downward development is possible because the rock in the buffer zone is sufficiently tight to hold back the river water.

Two inactive quarries are located in a different part of the dolostone sequence on the west bank of the Hudson opposite New Hamburg at Cedar Cliff. In these quarries the dolostone is locally characterized by considerable chert of a variety that is known to have a deleterious effect when used as concrete aggregate. If reopened, selective quarrying would be necessary until new advances in concrete technology nullify these effects. There is no reason why other applications are not possible, provided the rock meets the necessary specifications.

Retrace route past screen house and storage silos.

Cumulative Mileage	Distance between points	
18.3	0.3	Overhead conveyer belt. Note dolostone on left dipping gently southwestward.
18.4	0.1	Cross bridge over N.Y. Central Railroad and turn north (left) into quarry.
18.6	0.2	Lowest operating level on right; 42-inch gyratory primary crusher on left.
19.0	0.4	Continue north by bearing slightly left on road through riprap storage area.
19.1	0.1	Stop to examine and sample dolostone.
19.2	0.1	Northwest quarry wall on left. Note steepening of dip near northwest border of dolostone fault block, minor normal faulting (one layer displaced about one foot), and close block jointing. Normal gentle dip is shown on north wall of quarry.

Cumulative Mileage	Distance between points	
19.4	0.2	Remnant of glaciofluvial fill on irregularly eroded bedrock containing buried stream channels and sink holes. View area on foot. Drill core data gives evidence that uniform gentle dip in main quarry area changes into broad gentle folds to north. Present north face shows steepening of dip.
		Retrace route to crusher area.
20.0	0.6	Primary crusher on right. View crushing operation if time permits.
		Time: 11:10 A.M.
20.3	0.3	Leave N.Y. Trap Rock. Turn left at east end of bridge over railroad.
21.3	1.0	Turn north (left) on Sheafe Road at end of quarry road.
22.0	0.7	Turn east (right) on Old Post Road and proceed uphill.
22.2	0.2	Turn north (left) on Route 9 (Albany Post Road) at traffic light.
24.1	1.9	Note Marlboro Hills on left across Hudson River beyond IBM plant. These hills are composed of tough, resistant graywackes and fine sandstones of the Austin Glen Member, Normanskill Formation.
26.0	1.9	Entering City of Poughkeepsie.
26.8	0.8	View of Hudson River and Mid-Hudson Bridge.
27.6	0.8	Exit left for Mid-Hudson Bridge.
27.9	0.3	Toll Gates.
28.5	0.6	West end of Mid-Hudson Bridge. Note excellent exposures of Normanskill Formation (Austin Glen Member) showing massive graywackes with interbedded slaty shale.
29.1	0.6	More excellent exposures of the Austin Glen Member.
29.5	0.4	Highland Traffic Circle. Turn north (right) to Kingston via Route 9W.
33.3	3.8	End of divided highway.
33.6	0.3	Good view of Hudson River on right with Eymard Seminary on bluff across river.
43.2	9.6	Rondout Creek Bridge (tidewater inlet). Cross bridge and continue straight uphill on Route 9W.
43.8	0.6	Turn right at "T" intersection, remaining on Route 9W.
44.2	0.4	Traffic light. Leave Route 9W by continuing straight ahead on Route 28 (Broadway).
		Time: 12:00 Noon
44.6	0.4	#REST STOP (15 minutes)

#REST STOP: Trailways Bus Terminal

Corners of Broadway and Pine Grove Street, Kingston. Lunch is planned for STOP 3 where ample time will be available because a short tour of the facilities can be accomplished only in small groups. It is possible that some participants may not be able to wait until 1:00 or 1:30 P.M. Those who wish to obtain a quick snack or a candy bar may do so here.

Time: 12:15 P.M.

Cumulative Mileage	Distance between points	
44.6		Leave Trailways Bus Terminal and continue west on Broadway. Turn left at the second traffic light past the New York Central Railroad underpass onto Route 32 (Henry Street).
44.9	0.3	Turn left on Henry Street (Route 32).
45.4	0.5	Turn left on Fair Street (one-way), Route 32.
45.5	0.1	Continue on Route 32 at intersection by bearing half right on Boulevard.
46.1	0.6	Gentle anticlinal fold in Schoharie Formation on left.
47.3	1.2	Traffic light for Nytralite truck crossing. Turn right into quarry.
		Time: 12:30 P.M.
47.5	0.2	STOP 3 (Two hours)

STOP 3: Nytralite Aggregate, Inc. - Quarry and Tour of Plant

Nytralite Aggregates, Inc. is one of the leading producers of lightweight aggregate in the Mid-Hudson Valley. Lightweight aggregates are special materials incorporated with cement in the manufacture of concretes which range in weight from 120 pounds per cubic foot to less than 62 pounds per cubic foot. The latter is able to float on water. By comparison, conventional concretes containing other aggregates, such as crushed carbonate rock seen at Stop 2, weigh about 150 pounds per cubic foot.

Lightweight aggregate is used in substantially more than half of the concrete block produced in the United States. The desirable properties gained by this usage are: lightness, high strength-to-weight ratio, low shrinkage, low thermal conductivity, good acoustical properties, a coefficient of expansion similar to that of steel and low production costs. The use of lightweight aggregate in the concrete roadway of San Francisco-Oakland Bay Bridge reduced the cost of steel by three million dollars.

Lightweight aggregate may be manufactured from clay or shale by heating these substances until they expand to form porous, cinder-like materials. Expansion is a bloating process in which two conditions occur simultaneously. Upon firing, the clay or shale fuses to form a viscous liquid, while at the same time, a gas, released as a result of mineral decomposition, becomes entrapped within the viscous mass. If the gas-producing mineral, or minerals, decomposes before any appreciable liquid formation takes place, expansion will not occur, as the gas will escape through the open-pore structure. Satisfactory expansion also will not occur if the gas is evolved at temperatures much greater than the softening point, as the gas will again be lost because the melt will be too fluid to retain it. If, for some reason, the gas is retained under this condition, cells may be too large and their walls too thin for good strength.

Non-bloating argillaceous materials can often be induced to expand by adding pulverized coal and pelletizing into desired size prior to ignition.

The rock most suitable for the manufacture of lightweight aggregate is a massive, somewhat silty (arenaceous), unweathered shale of uniform quality. It may contain a small amount of calcite, either disseminated or as thin veinlets, and a little pyrite. Slaty cleavage should not be well developed, but it causes no problem in its incipient stages. This type of rock yields a good, uniform aggregate of adequate strength and an acceptable appearance. It bloats at approximately 2000 degrees F. The Esopus Shale exposed in the Nytralite quarry fits this description. Note the gentle dip of the massive beds to the southeast (north face) and nearly vertical cleavage (east face). The quarry is located on the gently-dipping western limb of an asymmetrical syncline, the axial planes of which dips to the southeast. The trace of the axial plane is roughly parallel to the crest of Fly Mountain. Fly Mountain is basically a northeast-trending asymmetric synclinal ridge characterized by a number of similarly-trending subsidiary folds. It is composed mainly of Late Silurian and Early Devonian carbonate rocks (Figures B3, B4) which have been thrust northwestward over the Esopus Shale along multiple faults. Exit quarry.

Cumulative Mileage	Distance between points	
47.6	0.1	Cross Route 32 and proceed up road to plant.
47.8	0.2	Exit buses and proceed on foot. Note initial test quarry in Esopus Shale to north. Walk up hill, noting the carbonate rocks, to primary crusher and Plant Office. Route essentially parallels the section given in Figure B4.
48.2	0.4	Plant Office. Lunch stop and tour of plant. Refer to flow diagram (Figure B5).
		Time: 2:30 P.M.
48.2		Leave Nytralite Aggregates, Inc. Board buses, returning to Route 32.
48.7	0.5	Turn south (left) at traffic light on Route 32. The Esopus Shale crops out along the north (right) side of the road for the next half a mile.
49.2	0.5	The Esopus Shale is exposed on both sides of Route 32.
50.0	0.8	End of Esopus outcrop. For the next 1.3 miles, various Lower Devonian formations are exposed in road cuts but the rapid changes in lithology do not permit recognition from the bus window.
51.3	1.3	N.Y. State Thruway (officially the Gov. Thomas E. Dewey Thruway).
52.9	1.6	Rosendale Shopping Center on right.
53.0	0.1	Turn southwest (right) on Route 213 through the village of Rosendale.
53.7	0.7	Abandoned natural cement mines on right.

Cumulative Mileage	Distance between points	
53.8	0.1	Pass under railroad trestle.
53.9	0.1	Sharp right turn uphill to north on Binnewater Road.
54.2	0.2	Vertical continuous draw type kilns used by the Century Cement Co. in the manufacture of natural cement of left. These kilns, built in batteries, are about 40 feet high, 10 feet in diameter and lined with refractory brick. The charge is made up of alternate layers of crushed natural cement rock and anthracite coal. It is loaded from the top of the kiln and consists of three 2.5-foot layers, consisting of 7-inch, 2 to 4-inch and 2-inch fragments, in that order. The crushed natural cement rock layers are separated from one another by approximately 3 inches of pea-sized anthracite coal (equal to 10 percent of the natural cement raw material) and the procedure is repeated. Burning takes four days. Loading is done so that one-fourth of the calcined rock is withdrawn each day and a proportionate new charge of raw stone and fuel to refill the kiln is added to the top. From the kiln, portable pan conveyers are used to transport the burnt material to trucks for delivery to the mill. At the pan conveyor the material is hand picked, so that any under- or over-burned clinker is discarded. At the mill, the clinkers are put through a series of crushing, pulverizing and finish grinding and then conveyed to silos to await shipment.
54.8	0.6	Turn left at Keator's Corner on Sawdust Ave.
55.2	0.4	Turn left into truck entrance for the Century Cement Mfg. Co., staying on hard surface road (right).
55.6	0.4	Century Cement Mfg. Co., Inc. mill. This mill is unique in that it uses the only vertical cement kiln in this country. The raw mix - largely a controlled blend of Becraft Limestone (from quarry across road on right) and Mt. Marion Shale (imported)— is pulverized, combined with powdered coal and pelletized before firing. Masonry and portland cements are produced.
55.7	0.1	Plant Office. Proceed straight ahead to underground operation.
55.8	0.1	View of Shawangunk Mountain and the fire tower at Lake Mohonk. Shawangunk Mountain is capped by very resistant quartzite and quartz pebble conglomerate of the Shawangunk Formation which lie with distinct angular unconformity on the intricately folded Normanskill (Martinsburg) shales.
		Time: 3:00 P.M.
56.0	0.2	STOP 4: (One hour)

STOP 4: Natural Cement Mine, Century Cement Mfg. Co.

Natural cement is produced by calcining an impure, argillaceous limestone or dolomitic limestone containing from 15 to 40 percent silica, alumina, and iron oxide at a comparatively low temperature (about 1400° F.) so that decarbonation but no fusion takes place. The burned mass will not slake if water is added, but when ground to a powder it will harden rapidly with the addition of water. Natural cement acquires most of its untimate strength in 5 years and only one-eighth of its ultimate strength in 7 days whereas most portland cements approach their ultimate strength in one year and reach 65 to 75 percent of their ultimate strength in 7 days.

In the United States, the cement industry began in 1818 with the discovery of natural cement rock near Chittenango, New York, by Canvass White. White applied to the State of New York for exlcusive rights to manufacture the cement for 20 years. His request was denied but the State awarded him $20,000 in recognition of his valuable discovery. The cement was used in the construction of the Erie Canal.

In 1825, during the building of the Delaware and Hudson Canal, a natural cement rock was discovered here at Rosendale. Work was progressing along the route of the canal through the farm of Jacob L. Snyder when it became necessary to blast through some rock. The rock, as blasted, had the appearance of limestone and fragments were taken to a blacksmith shop at High Falls to produce lime. The stone was burned in the forge and attempts to slake it were made by adding water. The calcined material, soft and chalky after burning, did not slake but instead, after a few hours, lost all of its chalkiness and began to harden. It had been planned to obtain the cement necessary for the canal locks from Chittenango but with the discovery of cement along the route, a contract was awarded to a Mr. John Littlejohn to supply the canal's needs. Littlejohn built a "pot" kiln in which the burning of each charge was a separate operation. The pot kiln was a shaft excavated in the side of a hill and lined with cement rock. At the base of the kiln, an "eye" or shaft at a right angle to the main shaft was filled with cordwood and an arch of large cement rocks, to act like a grate, was formed just above the cordwood. The kiln was then filled with cordwood and an arch of large cement rocks, to act like a grate, was formed just above the cordwood. The kiln was then filled with broken cement rock and the cordwood ignited. The burning continued until the highest stone in the kiln was calcined (5 to 6 days) and then the entire charge was withdrawn. The kiln was then recharged and the procedure repeated.

The charge, as drawn, contained some raw and some over-burned materials. These were carefully removed and the raw material was used in the next kiln charge while the over-burned material was discarded. This procedure was necessary not only from a technical standpoint but also from a mechanical one. The mill equipment would grind neither the hard over-burned clinker nor the hard under-burned stone. The grinding equipment was fashioned on the same principle as a grist mill, utilizing millstones made from the quartz pebble conglomerate or "grit" of the Shawangunk Formation. The growth of the natural cement industry fostered a sizeable millstone business.

The rocks in the Rosendale district are so intricately folded and faulted that natural cement raw materials crop out almost everywhere. Repeated exposures are clearly indicated by the many abandoned mines in the region and it is obvious that the early miners knew what to look for. The natural cement rock was at first quarried but eventually it became necessary to drive headings and open a mine where the dip carried the desired rock below the surface. To aid visibility, it was customary to mine down dip a certain distance, return to the outside, and create a similar new opening 30 feet or so along the strike. These headings would then be worked at right angles until they were connected. The procedure was repeated again and again, leaving a series of adits, which provided the light to work with, separated by 30-foot pillars. As it became necessary to penetrate deeper underground, illumination was provided by kerosene torches and the miners copied from their successful adits the scheme of leaving 30-foot pillars to support the roof. This room and pillar arrangement is clearly demonstrated in the Century Cement mine.

Natural cement production in the United States grew from 100,000 bbls. a year in the 1830's to 10,000,000 bbls. per year in 1899. At the peak of the industry, in the Rosendale district, some 20 plants employed 5,000 men and turned out 4,000,000 bbls. per year.

About 1894, portland cement, a carefully controlled blend of cement raw materials to insure uniformity, came into general use. In 1900 production of natural cement and portland cement was identical, 8,500,000 barrels each. During the early 1900's, the first large structure of its type to be entirely constructed with portland cement was the Boonton Dam in New Jersey. The Boonton Dam was to be a part of the water supply of Jersey City and Rosendale natural cement was originally specified for its construction. However, a director of the Alpha Portland Cement Company was a member of the Board of Water Supply and he proposed to supply the Jersey City job with portland cement from his company at the same cost as Rosendale natural cement. The dam was built with portland cement. Then portland cement gained ascendency over natural cement and by 1910 natural cement production throughout the United States was reduced to about 1,000,000 bbls. The plants began to close down after the start of the 20th century and by 1920 only one plant remained in the Rosendale district - Century Cement. In fact, this company is the only producer of natural cement in the United States today and that on a limited basis.

The natural cement produced in the Rosendale district is a low lime, high silica, high magnesia, hydraulic cement of pozzolanic properties. A typical chemical analysis of the raw cement rock (Rosendale Member of the Rondout Formation) mined by Century Cement is:

SiO_2	17.5
Al_2O_3	5.0
Fe_2O_3	2.8
$CaCO_3$	41.5
$MgCO_3$	31.5
Alkalies	1.7
Total	100.0%

The working faces are now about half a mile from the mine entrance and slightly more than 100 feet below the surface. Production is presently limited to the Rosendale Member.

A significant portion of the mined-out lower level has been leased for the underground storage of vital records. Construction of vaults and other preparations are in progress.

MINE SECTION
CENTURY CEMENT MFG. CO.

Manlius Formation

——— roof, upper level; 2' below Manlius Fm.

Rondout Formation

Whiteport Member 14'

——— floor, upper level

Glasco Member 14'

——— roof, lower level

Rosendale Member 22'

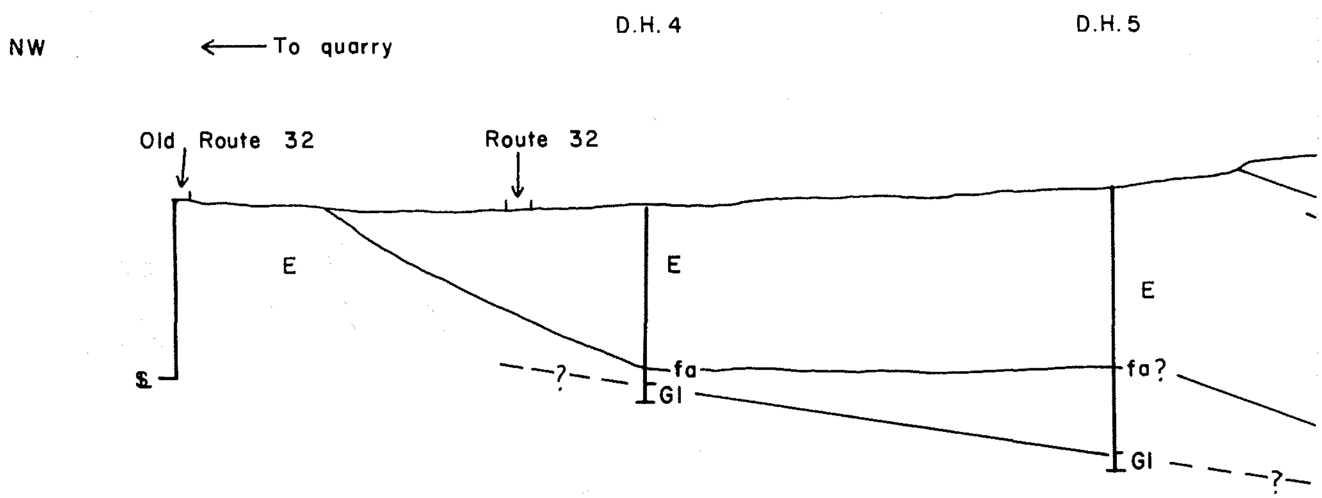
——— floor, lower level (mine entrance)

Binnewater Formation

Cumulative Mileage	Distance between points	
		Time: 4:00 P.M.
56.0		Retrace route past office and mill.
56.9	0.9	Turn right on Sawdust Ave., returning to Keator's Corner.
57.3	0.4	Keator's Corner. Stop sign. Turn right on Binnewater Road.
58.2	0.9	Turn sharp left at stop sign onto Route 213, returning to Rosendale.
59.0	0.8	Turn south (right) on Route 32 and follow signs for the N.Y. Thruway.
59.2	0.2	Abandoned natural cement mine on left.
61.4	2.2	Bridge across the Wallkill River.
62.8	1.4	Good view of Shawangunk Mts. on right.
65.3	2.5	Entering New Paltz.
65.9	0.6	Continue straight on Route 208.
66.1	0.2	East (left) on Main Street (Routes 299 and 32). Follow uphill through village of New Paltz
66.5	0.4	Traffic light. Continue straight on Route 299 (leaving Route 32) to Thruway interchange 18.
67.4	0.9	Enter N.Y. Thruway on right, proceed south to Newburgh (Exit 17) and Holiday Inn.
83.4	16.0	Holiday Inn.

FIGUR

Geologic section across
southwest of
(after J. H.



E	Esopus Formation	
Gl	Glenerie Formation	
Co	Connelly Formation	
PE	Port Ewen Formation	
B	Becraft Formation	
NS	New Scotland Formation	
K	Kalkberg Formation	
C	Coeymans Formation	
M	Manlius Formation	
R	Rondout Group	
SL	Sea Level	
↔	Anticlinal Axis	
✱	Synclinal Axis	

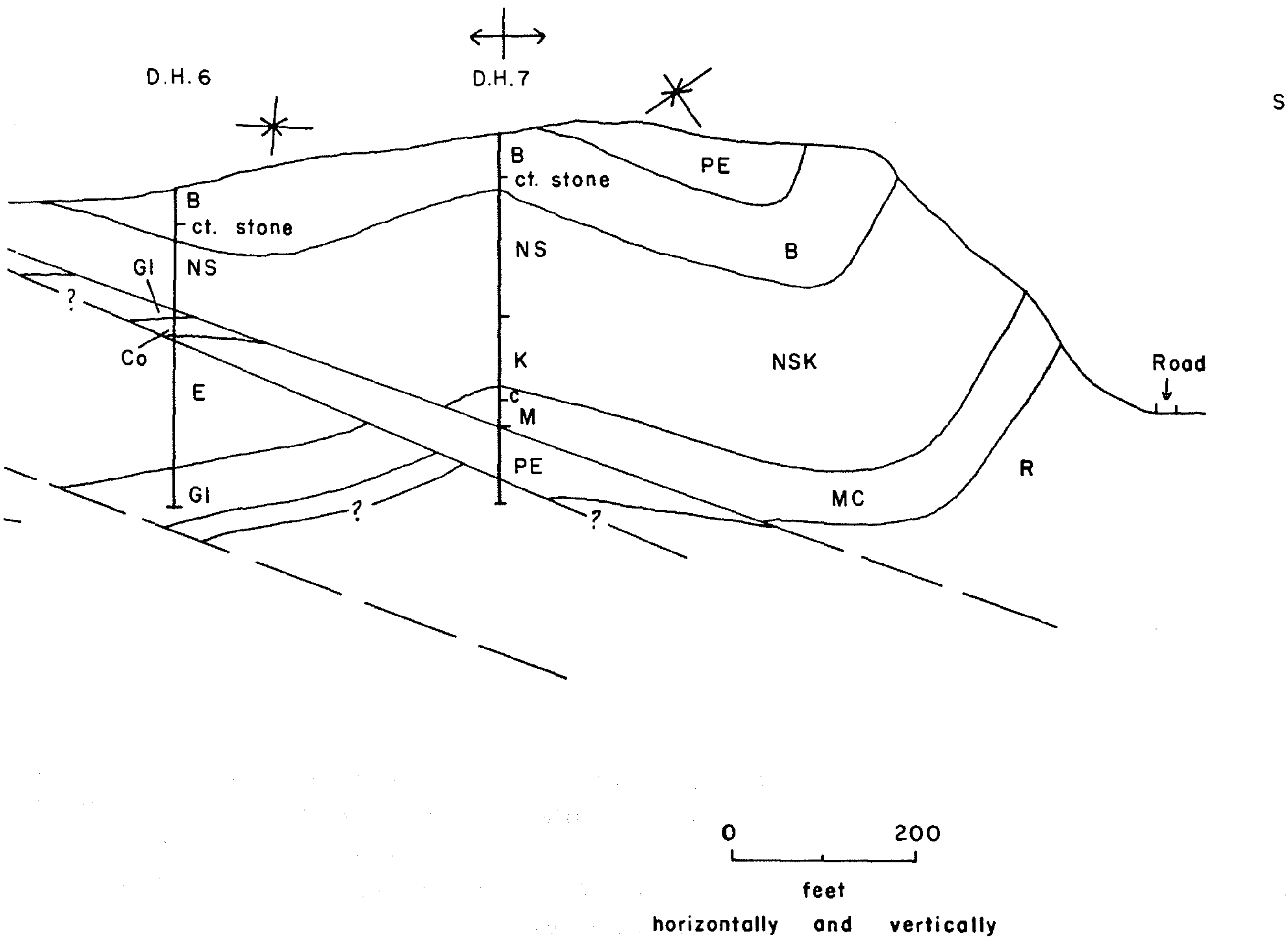
for more complete legend information see Figure B3

· B4

ly Mountain 1,500 feet

Figure B3

Johnsen)



BBarton

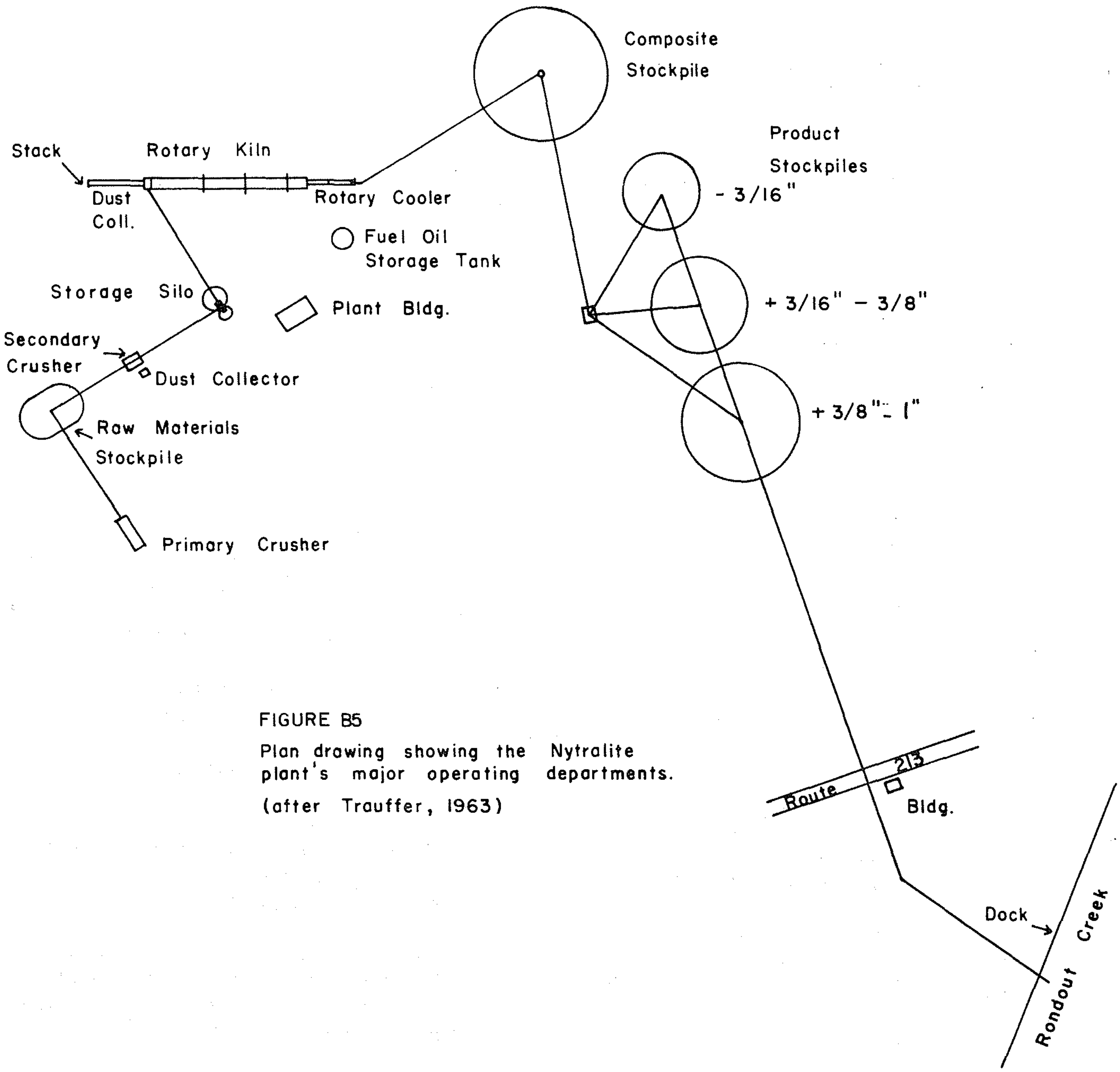


FIGURE B5

Plan drawing showing the Nytralite plant's major operating departments.

(after Trauffer, 1963)

BBarton

TABLE B1

GENERALIZED GEOLOGIC SECTION FOR THE MID-HUDSON VALLEY

FORMATIONS (Thickness in feet)	PRINCIPAL LITHOLOGY
DEVONIAN PERIOD	
Middle Devonian	
Plattekill Fm. (800)	Reddish-purple mudstones and silt-stones, dark-gray shales and impure sandstone
Ashokan Fm. (300)	Bluish-gray sandstone (flagstone), olive-gray shale
Mt. Marion Fm. (800)	Gray sandstone and shale
Bakoven Fm. (200)	Black shale
Onondaga Fm. (170-180)	
Moorehouse Member (100+)	Gray limestone with dark-gray chert
Nedrow Member (35)	Gray limestone
Edgecliff Member (35-40)	Gray coralline limestone with light-gray chert
Lower Devonian	
Schoharie Fm. (74-222)	
Saugerties Member (18-77)	Medium-gray argillaceous limestone and calcareous mudstone
Aquetuck Member (30-45)	Calcareous mudstone and siltstone with some gray argillaceous limestone; occ. chert
Carlisle Center Member (26-124)	Calcareous dark-gray siltstone and mudstone
Esopus Fm. (150-200)	Dark-gray shale and siltstone
Glenerie Fm. (20-55)	Dark-gray siliceous limestone with chert
Connelly Fm. (0-20)	Gray conglomerate and sandstone
Port Ewen Fm. (10-100+)	Gray argillaceous limestone with inter-bedded shale
Alsen Fm. (20-25)	Dark-gray limestone with some chert
Becraft Fm. (35-50)	Gray to pinkish-gray crinoidal limestone
New Scotland Fm. (95-150)	Dark-gray calcareous mudstone and argillaceous limestone
Kalkberg Fm. (75)	
Broncks Lake Member (43)	Gray argillaceous limestone and limestone with some dark-gray calcareous shale
Hannacroix Member (32)	Dark-gray to gray limestone, gray shale partings, chert at base
Coeymans Fm.	
Ravena Member (20-28)	Medium-gray to gray limestone
Manlius Fm.	
Thacher Member (48-50)	Dark-gray to medium-gray limestone, occ. laminated; magnesian at base

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SILURIAN PERIOD

Upper Silurian	
Rondout Fm. (30-55)	
Whiteport Member (4-16)	Gray argillaceous magnesian limestone
Glasco Member (10-13)	Gray coralline limestone
Rosendale Member (6-27)	Gray argillaceous magnesian limestone
Wilbur Member (4-12)	Medium-to light-gray limestone
Binnewater Fm. (0-35)	Blue-gray to greenish-gray cross-bedded, occ. ripple-marked quartz sandstone
High Falls Fm. (0-85)	Red and green shale
Middle Silurian	
Shawangunk Fm. (0-6004)	Milky white to gray quartzite and quartz pebble conglomerate

MAJOR UNCONFORMITY

ORDOVICIAN PERIOD

Middle Ordovician	
Normanskill Fm. (2000)	
Austin Glen Member (1200+)	Graywackes, black and gray shale and siltstones
Mount Merino Member (250+)	Black shale and chert with local red and green shales
Lower Ordovician	
Stockbridge Group (Wappinger carbonate sequence)	
Balmville Fm. (70)	Gray limestone
Copake Fm. (400)	Dark-gray dolomite with some limestone
Rochdale Fm. (750)	Light-blue-gray limestone, some dolostone
Halcyon Lake Fm. (350)	Light-gray dolimitic limestone

CAMBRIAN PERIOD

Upper Cambrian	
Stockbridge Group (con'd.)	
Briarcliff Fm. (700)	Light-gray dolostones
Pine Plains Fm. (1475)	Light-gray, slightly sandy dolostone, some sandstone and shale
Middle and Lower Cambrian	
Stissing Fm. (500)	Gray dolostone, some with chert
Lower Cambrian	
Poughquag Fm. (300)	Gray quartzite

MAJOR UNCONFORMITY

PRECAMBRIAN (exposed in the Hudson Highlands)

TABLE B2

USES OF THE ROCK FORMATIONS IN THE MID-HUDSON VALLEY

Plattekill Fm.	Extruded wire cut brick
Ashokan Fm.	Flagstone
Mt. Marion Fm.	Extruded wire cut brick, argillaceous component in portland cement
Onondaga Fm.	Crushed stone, portland cement, locally blast furnace flux and agricultural limestone
Esopus Fm.	Lightweight aggregate, argillaceous component in portland cement
Glenerie Fm.	Crushed stone, portland cement*
Port Ewen Fm.	Crushed stone, portland cement*
Alsen Fm.	Crushed stone, portland cement*
Becraft Fm.	Portland cement, crushed stone, agricultural limestone
New Scotland Fm.	Crushed stone, portland cement*
Kalkberg Fm.	Crushed stone, portland cement*
Coeymans Fm.	Crushed stone, portland cement*
Manlius Fm.	Crushed stone, portland cement, blast furnace flux, agricultural limestone
Rondout Fm. (Rosendale & Whiteport Members)	Natural cement
Normanskill Fm.	Extruded wire cut brick, possibly lightweight aggregate
Briarcliff Fm.	Crushed stone, riprap
Pine Plains Fm.	Crushed stone, riprap

*When mixed with purer limestones such as Becraft, Coeymans or Manlius