TRIP C

SILURIAN AND DEVONIAN ROCKS OF THE CENTRAL HUDSON VALLEY

By James R. Dunn
Dept. of Geology, Rensselaer Polytechnic Institute
and
Lawrence V. Rickard*
N.Y. State Geological Survey, Albany, N.Y.

INTRODUCTION

Limestones, shales, sandstones, and conglomerates comprise the Silurian and Devonian sequence of the Hudson Valley. Only the youngest portion of the Late Silurian is represented (Rondout Formation), whereas most of the Early and all of the Middle Devonian is present. Late Silurian (Cayugan Series) rocks are thin, and rest unconformably upon folded and eroded Middle Ordovician shales and sandstones. The Early Devonian rocks are divided into the Helderbergian and Ulsterian Series (Rickard, in press), and consist of limestones in the lower part and shales and sandstones in the upper portion. The overlying Middle Devonian sequence (Erian Series) begins with the Onondaga Limestone and continues above into marine and non-marine shales and sandstones of the Hamilton Group. Fossils are common throughout most of the Silurian-Devonian sequence of the Hudson Valley. Marine assemblages are particularly rich in the Helderberg limestones, the Onondaga Limestone and the lower, marine portion of the Hamilton. Plant fragments are the only abundant fossils in the non-marine rocks near the top of the sequence.

STRATIGRAPHY

UPPER SILURIAN AND LOWER DEVONIAN

Introductory Statement

Extensive detailed geologic mapping on a scale of 100 feet and 50 feet to the inch by Dunn, Cutcliffe, and LaBrake in the South Bethlehem-Ravena area and the Port Ewen-East Kingston area, and analyses of thousands of feet of diamond drill cores have provided new detailed information about the Cayugan and Helderbergian formations in the Hudson Valley. An outgrowth of the work has been a division of the Manlius, Kalkberg, and New Scotland formations into new, economically usable key beds and members. Simultaneously, L. V. Rickard (in press) has studied the same series on a regional basis and has redefined and subdivided several formations. Plate I is a tabulation of the geologic formations from previous authors and indicates the new stratigraphic units suggested by Rickard (in press), and Dunn, et al., (unpublished), as seen at East Kingston, Broncks Lake and Ravena.

*Published by permission of Ass't. Commissioner, N. Y. State Museum and Science Service.

Stratigraphic Summary for the Ravena Area, New York

Age	Series	Formations	Members	Lithologies
MIDDLE DEVONIAN	ERIAN	Hamilton Group	Kiskatom	Shale to sandstone
			Ashokan	Sandstone
			Mount Marion	Shale to sandstone
			Stony Hollow	Shale
			Bakoven	Shale
		Onondaga	Nedrow	Limestone
			Edgecliff	Limestone
LOWER DEVONIAN	ULSTERIAN	Schoharie	Leeds	Calcareous mudstone to limesto
			Carlisle Center	Calcareous mudstone
		Esopus		Shale to sandstone
		Glenerie		Quartz sandstone
	HELDERBERGIAN	Becraft		Limestone
		New Scotland		Calcareous mudstone to limesto
		Kalkberg	Broncks Lake	Limestone
			Hannacroix	Limestone
		Coeymans	Ravena	Limestone
		Manlius		Limestone
Late SILURIAN	CAYUGAN	Rondout		Limestone
Middle ORDOVICIAN		Normanskill		Shale to sandstone

Rickard has suggested that part of the Rondout Formation (the Crysler Member) and the Manlius Formation be placed in the Devonian and that the Crysler Member be made the base of the Helderbergian Series. He also has defined the Thacher Member of the Manlius and the Ravena Member of the Coeymans. He has redefined the top of the Kalkberg and suggests that the Kalkberg be given formational status.

J. R. Dunn, assisted by W. E. Cutcliffe and R. LaBrake, has described six key beds within the Manlius Formation that have proven to be mappable units throughout the central Hudson Valley. The Kalkberg Formation has been subdivided into four units on the basis of lithologic and faunal criteria. Faunal, lithologic, and chemical data obtained by Dunn support Rickard's redefinition of the top of the Kalkberg Formation. The New Scotland Formation has been described in detail from numerous cores, and several key beds have been noted. A facies change from predominantly calcareous mudstone to silty limestones occurs from north to south.

Upper Silurian

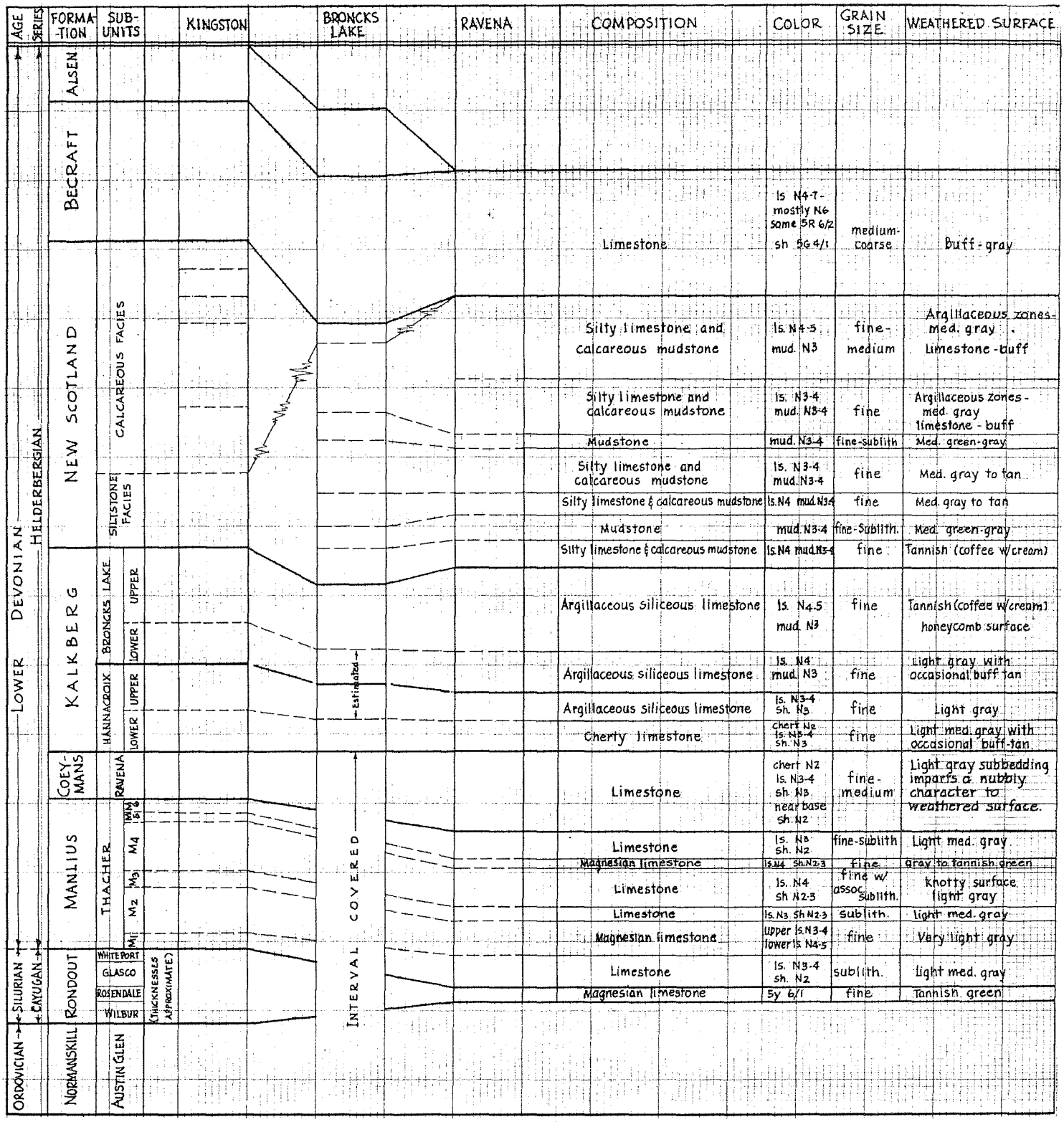
Rondout Formation

The name Rondout was first applied by Clarke and Schuchert (1899, pp. 874-876) to magnesian limestones in the vicinity of Rondout which were used for the manufacture of natural cement. Rickard (in press) defines the Rondout Formation as the buff-weathering, greenish-gray, magnesium limestone which is subjacent to the Manlius Formation throughout New York State. Because no specific type locality was recommended in the past, Rickard suggests that the exposures in the abandoned gravel pit 0.5 miles south of Wilbur, New York be taken as the standard reference section. He notes that other equally good sections are present at the abandoned cement mine in East Kingston and along the road south of the West Shore railroad bridge at Wilbur. The Rondout of southeastern and eastern New York is considered by Rickard to be Upper Silurian (Late Cayugan). The Crysler Member of central New York is placed in the Devonian (Early Helderbergian).

The Rondout, as presently defined in the central Hudson Valley, is the buff-to gray-weathering, magnesian limestone which lies between the contorted Ordovician shales, siltstones, and graywackes and the ash-gray-weathering, blue-gray, predominantly thin-bedded limestone of the lowest Manlius Formation. Fresh Rondout Limestone has a greenish cast, particularly in the more magnesian zones. These zones in all cases are fairly high in ferrous iron and in pyrite and hence weather characteristically to a buff color. Locally, the Rondout is rich in the corals Halysites catenularia and Cladopora rectilineata.

In the vicinity of Rosendale and Kingston, the Rondout is divided, from bottom to top, into the Wilbur Limestone (3-15 feet), the Rosendale Dolomitic Limestone (17-27 feet), the Glasco Limestone (10 to 15 feet), and the Whiteport Dolomitic Limestone (9-14 feet). The Rondout is 37feet thick at Wilbur, 40 feet at Fourth Lake, and almost 50 feet at Rosendale according to Rickard (in press). Diamond drill cores indicate a thickness of about 28 feet at East Kingston. A thickness of approximately 30 feet

SUMMARY OF LATE CAYUGAN AND HELDERBERGIAN



COLOR CODE

REFERENCE: ROCK COLOR CHART
GEOLOGIC SOCIETY OF AMERICA, N.Y., N.Y.

N2 - Grayish Black	N5 - Medium Gray	5G4/1 - Dark Greenish Gray
N3 - Dark Gray	N6 - Medium Light Gray	5Y6/1 - Olive Gray
N4 - Medium Dark Gray	N7 - Light Gray	5R6/2 - Pale Red

STRATIGRAPHY IN THE CENTRAL HUDSON VALLEY

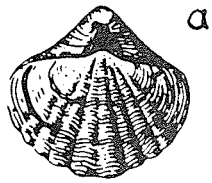
TOPOGRAPHIC EXPRESSION	BEDDING	COMMON FAUNAL SPECIES	SPECIAL CHARACTERISTICS
Slope			
Cliff } slope	Massive (1-2' beds) Lower 10" - 8-16" of Limestone with ½-6" shale	Abundant fossils - Spirifer concinnus, Gypidula pseudogaleata, Atrypa reticularis and Uncinulus campbellanus	Becraft <25% shale, crystalline limestone frequently a coquinoid. New Scotland contact is transitional. Base is last typical gray New Scotland limestone with first green-gray Becraft shale superjacent.
Slope	Limestone 2"-10" beds Mudstone ½-2" at top to 12-15" near base	Transitional Becraft fauna Leptaena rhomboidalis immediately below contact. Lower part of zone, Streptelasma strictum abundant.	New Scotland >25% mudstone generally ≈60%. Limestone, crinoids, with slight Becraft texture. Three fossiliferous blue-gray-black chert bands, one above, two below Becraft contact.
Cliff } slope	Limestone 1-4" beds Mudstone 12-36" beds	Abundant large brachiopods, "Eospirifer" macropleura, Leptaena rhomboidalis, Leptostrophia becki, Strophonella leavenworthana.	Main cliff former
Slope	Limestone 2-6" beds, Mudstone 6-12" beds	Leptostrophia becki (?)	Fossils jumbled, small olive green pebbles.
Slope	Limestone 2½-10" beds Mudstone 16" beds	Some large brachiopods, abundant small rugose corals. Few algal swirls. Streptelasma strictum	Limestone zones weather with ½" wide vertical scars, seldom outcrops.
Slope	Limestone 4-8" beds, Mudstone 4-19" beds	Large bryozoa whorls & algal reef pods in crystalline limestone.	Lithology similar to above unit.
Slope	Limestone 2-6" beds Mudstone 6-12" beds	Platyceras ventricosum, Rhipidomella oblata (?)	Fossils contorted. Associated limestone sublithographic in 8-13" beds. Olive green pebbles.
Slope	Limestone 1-2" beds Mudstone 8-12" beds	Lowest Eospirifer macropleura and abundant brachiopods.	Great increase in SiO_2 & Al_2O_3, decrease in CaO relative to lower unit.
Slope } cliff	Limestone 4-8" beds Mudstone 4-6" beds decreasing to ⅛-¼" beds near base.	Abundant rugose corals Few bryozoa whorls in lowest beds with relatively abundant brachiopods. Both decrease vertically.	3-4 layers of concentration of chert lenses near base of zone. Small nodules through lower half. Subbedding gives "tennis net" appearance.
Slope	Limestone 2-4" beds Shale ¼-½" beds	Abundant encrusting bryozoans; Dicoelosia varicus, Lingula rectilatera	Euxinic zone with pyrite and small calcareous fossil tests at base.
Slope	Massive (1-2') subbedding Shale streamers (1-3")	Small Gypidula coeymanensis, siliceous Crinoid stems, Dicoelosia varicus.	Lithology like Coeymans. "Tennis net" weathering.
Cliff	Massive (1-12") bedded with chert	Transition fauna - similar to Coeymans. Gypidula smaller, less common.	Abundant chert, otherwise like Coeymans.
Cliff	Thin bedded (1-2") for a few feet near the top & bottom. Massive (2-3') thru the main part with associated shale streamers.	Gypidula coeymanensis most common. Atrypa reticularis and Uncinulus mutabilis Large (½") siliceous crinoid stems.	Massive homogenous limestone with well developed vertical jointing. A few nodules of chert in upper beds. Contact transitional.
Slope	Limestone 2-6" beds Shale ⅛-¼" beds	Few Tentaculites gyracanthus. Stromatopora Barretti.	6-12" reef frequently in zone.
Slope	Millimeter	Generally absent.	Well developed in Ravena & west, intermittent to the South.
cliff	Irregular	Main reef builder Stromatopora (Syringostoma) barretti.	Interval immediately above & below well developed reef - light gray sublithographic limestone.
Slope	Limestone 2-6" beds, Shale ⅛-¼" beds	Tentaculites gyracanthus	Fossils recrystallized to sparry calcite.
Cliff	Millimeter	One foot zone in middle of unit with abundant Tentaculites gyracanthus	Polygonal mud crack structures. Color lightens beneath fossil zone.
Slope	2-4" Limestone bedded by ⅛-¼" shale Near base limestone 8-14" thick.	Tentaculites, "Spirifer" vanuxemi, Leperditia alta, and "Orthoceras" rudis.	"Orthoceras" rudis in small 2" zone immediately above Rondout contact in Ravena - small reef occasionally within zone. Contact conformable.
Slope	Millimeter to 1-8"	Absent in Ravena, Abundant & varied species in Kingston.	Radical facies change from Catskill to the South.

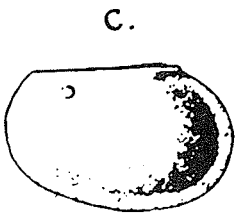
NOTE: Description of New Scotland is for Ravena Section.

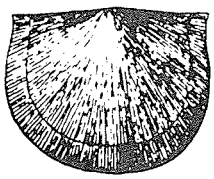
PLATE Ic

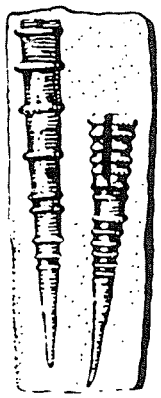
By W.E. Cutcliffe
Checked by J.R. Dunn

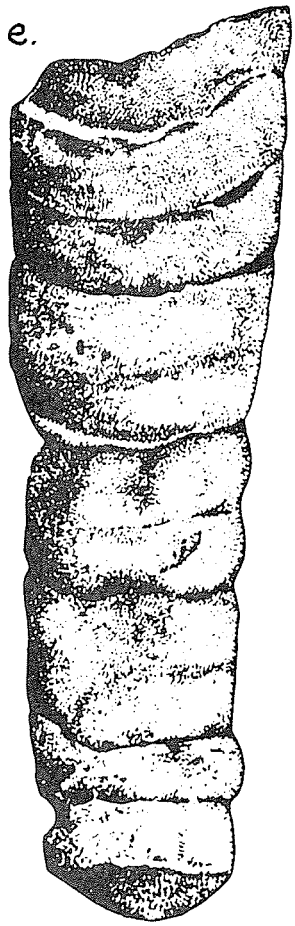
Vertical Scale 1" = 50'
March 1961



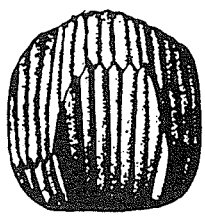




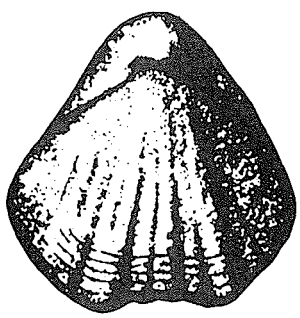


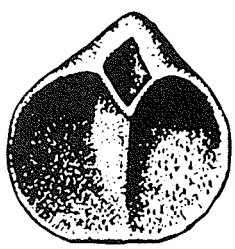


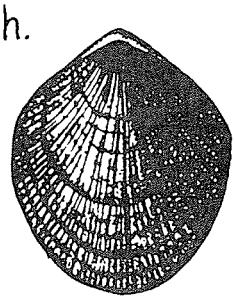
MANLIUS WATERLIME FOSSILS:
a. "Spirifer" vanuxemi, x 2¼. b. Stropheodonta varistriata, x 1⅛. c. Leperditia alta, x 3.
d. Tentaculites gyracanthus, x 3.
e. "Orthoceras" (Anastomoceras) rudis, x ¾.



COEYMANS LIMESTONE FOSSILS:
f. Uncinulus mutabilis, x 1⅛.
g. Gypidula coeymanensis, x 1⅛.
h. Atrypa reticularis, x 1⅛.







(Rickard, in press) is maintained northward to Catskill. The thickness in the Thacher Park and Ravena area is generally less than 10 feet but is variable. Cores at Ravena and South Bethlehem (western part of Callanan quarry) indicate 2 to 8 feet of Rondout magnesian limestone, but at the northern part of the Callanan Road Improvement Company quarry at South Bethlehem (Stop 1A) the Rondout Formation is 12 (?) feet thick.

Lower Devonian

Manlius Formation

The name Manlius was first used by Vanuxem (1840, p. 376) for limestone in the vicinity of Manlius, New York. Apparently it was first applied to rocks which are now known as the Cobleskill, Rondout, and Manlius Formations, but most subsequent applications of the name have restricted its use to only the last of these. The Manlius Formation is subdivided from bottom to top into the Thacher Member (Rickard, in press), and the Olney, Elmwood, Clark Reservation, and Jamesville Members (Smith, 1929). The Olney and higher members were to found pass laterally into the Coeymans Formation in the Richfield Springs quadrangle (Rickard, in press).

The only member of the Manlius Formation present in the central Hudson Valley is the Thacher. According to Rickard, the Thacher is not a part of the type Manlius as defined by Smith (1929). The Thacher consists of interbedded "ribbon" limestone and more massive biostromal units consisting of stromatoporoid remains. It has been subdivided by Dunn into 6 units, and these units have been utilized for detailed geologic mapping at South Bethlehem, Ravena, Coxsackie, East Kingston and Port Ewen. Plate I summarizes the units as seen at East Kingston and Ravena. The submembers are tentatively called M-1 through M-6. Of particular interest is the fact that the M-5 unit has a typical Rondout lithology, i.e., it is greenish gray, somewhat pyritic, weathers to a buff color and is magnesium rich. M-6, a medium bedded, frequently biostromal layer, is at the top of the Thacher.

The Thacher Member of the Manlius is 52 feet thick at the type locality at Indian Ladder in Thacher Park, 52 to 55 feet at Ravena and South Bethlehem, 50 feet at Broncks Lake, 52 feet at East Kingston, and 50 to 55 feet at Wilbur, Rondout, and Glasco southeast of Kingston (Rickard, in press). The fauna of the lower Thacher consists of Tentaculites gyracanthus (Eaton), Howellella vanuxemi (Hall), a brachiopod, and Leperditia alta (Conrad), and Howellella vanuxemi (Hall), among others. The stromatopore which is the major reef-former presumably is Syringostroma barretti (Girty). About 80 fossil species have been reported from the Thacher.

Coeymans Formation

The name Coeymans was first suggested by Clarke and Schuchert (1899, pp. 874-875) for the "Lower-Pentamerus" limestone of Hall, Vanuxem and others. The name was applied in some cases to include certain overlying strata, but subsequent usage by Ruedemann (1930), Goldring (1935), (1943), and Chadwick (1944) has restricted the Coeymans Formation to the essentially non-cherty units below the Kalkberg Formation and above the upper biostromal layer of

the Manlius Formation. The Ravena (new, Rickard 1961) is the only member of the Coeymans Formation which occurs in eastern New York. The Ravena Member of the Coeymans Formation is a homogeneous, bluish, medium gray, medium to coarse-grained limestone which forms prominent, massive ledges below the cherty Kalkberg Formation. It normally weathers to a slightly lighter gray than the overlying Kalkberg. Bedding planes are 1 to 12 inches apart and irregular enough in detail so that attitudes are difficult to obtain. The Ravena Limestone is characterized faunally by Gypidula coeymanensis (Schuchert) and large crinoid stems which, toward the top of the member, are silicified.

Rickard (in press) considers the upper contact of the Coeymans with the Kalkberg Formation to be gradational. Dunn identifies the top of the Coeymans in the Hudson Valley by the first occurrence of layers of chert nodules occurring about 12 inches apart. Johnsen (1958, p. 10) places this contact in the same position. Generally speaking, this selection places one or two nodular zones within the Coeymans Formation. However, in the absence of a more definitive contact the base of the closely spaced chert layers is quite adequate because: (1) this produces more uniform thicknesses for the Coeymans within a given area; (2) the base of the chert layers can nearly always be seen and is therefore readily mappable; (3) the increase in chert coincides with an increase in the silica content of the limestone, from less that 10% to about 25% - a point of considerable economic importance. This selection of the top of the Coeymans produces somewhat greater thicknesses for the Coeymans at Ravena than earlier reported. Based on many drill cores, Dunn recognized 26 to 30 feet. Johnsen observed 32 feet of Coeymans at Ravena. Typical thicknesses (Rickard, in press) for the Coeymans formation in the Hudson Valley are: Rosendale area 15 to 20 feet; Catskill quadrangle 10 to 15 feet; Ravena 20 feet; Indian Ladder in Thacher Park, 36 feet (50 feet according to Goldring 1935, p. 101).

Over 80 species of fossils have been reported from the Coeymans formation. Among the most common are: the brachiopods Atrypa "reticularis" (Linnaeus), Stropheodenta (Brachyprion) varistriata (Conrad), Gypidula coeymanensis (Schuchert), Uncinulus mutabilis (Hall), Camerotoechia semplicata (Conrad), Leptaena "rhomboidalis" Wilckens) and Rhipidomelloides oblata (Hall). The most common trilobites reported are Odontochile micrurus (Green) and Synphoroides pleuroptyx (Green).

Kalkberg Formation

In 1908, Chadwick (pp. 346-348) proposed the name Kalkberg for the cherty limestones in the lower part of the New Scotland Formation of Clarke and Schuchert (1899, pp. 874-878), with the apparent intention of giving the Kalkberg the status of a member. The name has been used primarily for the lower member of the New Scotland Formation although Hartnagel (1912, pp. 56-60) separated the Kalkberg from the New Scotland, giving them equal status. In the opinion of Rickard (in press) because "....the Kalkberg is much more extensive in central New York than the restricted New Scotland and contains a lithology and fauna distinct from strata above and below, it should be raised to formational rank and used only in that sense."

Chadwick placed the type locality of the Kalkberg at Austin's Glen on Catskill Creek where Rickard (in press) refers 54 feet of limestone to this formation. Earlier authors describing this section recognized only 40 feet

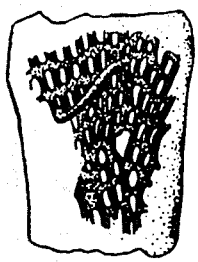
of Kalkberg and put the remaining part into the New Scotland or "Catskill shaly". Rickard's redefinition of the top of the type Kalkberg permits a clearer lithologic differentiation by placing all of the less shaly, medium to massive limestone units together. Faunal distinctions are also sharper - the Kalkberg includes the Dicoelosia (formerly Bilobites) varicus (Conrad) zone, and generally lacks Eospirifer macropleurus. (Conrad).

Independently, Dunn, working on cores and chemical analyses form East Kingston, South Bethlehem, and Ravena, arrived at a similar position for the top of the Kalkberg Formation. Criteria for separation were found to be not only faunal and lithologic but also chemical. Passage from Kalkberg, as now defined, into New Scotland is characterized by a change from less than 30% SiO_2 to nearly 50% SiO_2 and several percent Al_2O_3 or, stated lithologically, from siliceous limestone to calcareous mudstone.

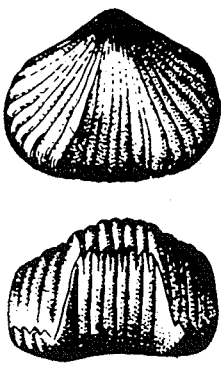
It is here proposed by Dunn that the Kalkberg Formation within the Hudson Valley be subdivided into two units which have been studied and differentiated in cores and in the field both in the Ravena-South Bethlehem area and the East Kingston area. The names here proposed are Hannacroix (lower and upper) for the lower unit and Broncks Lake (lower and upper) for the overlying unit. These two members have structural, faunal, and lithologic distinctions, but, aside from a slight upward increase in Al_2O_3 (from about 2% to 3.5%), the chemical composition of both members is very similar.

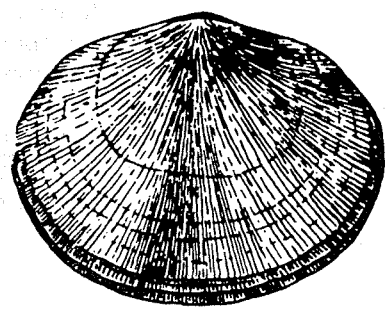
The lower Hannocroix is fully exposed in the field at many places from Albany to Kingston, because it is the principal ledge-forming unit west of the Hudson River. The lower Hannacroix is a bluish-gray, chert-rich limestone at the base of the Kalkberg, which, except for the chert, is very similar to the Coeymans Formation. It is fine grained, except for recrystallized fossils, and massive in appearance with bedding planes 4 to 12 inches apart. Nodular chert layers are spaced approximately 8 to 14 inches apart. The predominant species are large silicified crinoid stems, the brachiopods Dicoelosia varicus (Conrad), Gypidula coeymanensis (Schuchert) and Atrypa "reticularis" (Linnaeus). Typical thicknesses of the lower Hannacroix are 11 feet at Ravena and on Hannacroix Creek, 14 feet at Catskill, and 15 feet at East Kingston.

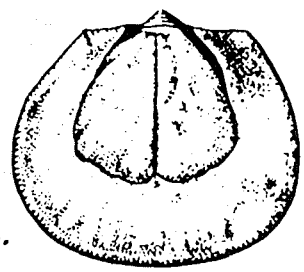
The upper Hannacroix is a fine-grained, fairly massive, gray limestone with anastomosing argillaceous subbedding and is the unit above the last layer of chert of the lower Hannacroix. Bedding planes are several inches to two feet apart. Although it contains none of the distinctive layers of chert nodules of the lower Hannacroix, it still contains about 25% SiO_2. This silica occurs as silt, fine chert replacements, and as a component in the clay fraction. On weathered bedding planes the rock is laced with thin shale stringers giving it a "tennis-net" appearance. In the absence of chert, this unit looks very similar to the Coeymans Formation, but is finer grained and contains only a few small shells of Gypidula coeymanensis (Schuchert). Other typical fossils are: Dicoelosia varicus (Conrad), Atrypa "reticularis" (Linnaeus), and Eatonia medialis (Vanuxem). The top of the Hannacroix is recognized by the first appearance of a dark gray, euxinic shale which contains pyritic nodules and small brachiopods. Typical thicknesses of the upper Hannacroix are 10 feet at Ravena and South Bethlehem, 14 feet at Catskill, and 14 to 18 feet at East Kingston.

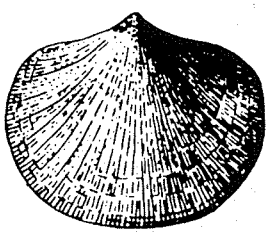


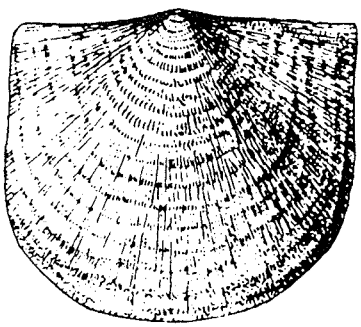
KALKBERG BEDS FOSSILS:
a. Bilobites varicus, ×3. b. Fenestrella compressa, ×1½.
c. Streptelasma (Enterolasma) strictum, × 1⅛.

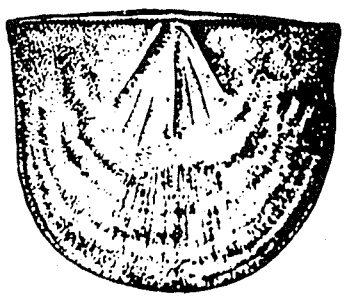


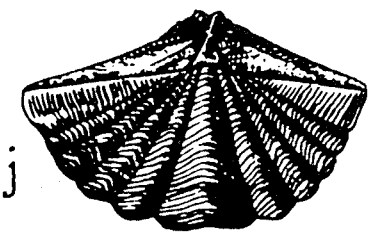












NEW SCOTLAND BEDS FOSSILS:
d. Uncinulus abruptus, × 1⅛. e. Rhipidomella oblata, × 1⅛, × 1½.
f. Isorthis perelegans, × 1⅛. g. Stenoschisma formosum, × 1⅛. h. Platyceras ventricosm, × 1½. i. Leptostrophia becki, × 1⅛, × ¾. j. "S" perlamellosus, × 1⅛.

The lower part of the Broncks Lake Member consists of fine-grained, blue-gray limestone beds, one to three inches thick, interbedded with calcareous shale layers, about 1 to 2 inches thick. This unit is not often exposed, but when it is, the hard limestone layers weather away from the argillaceous beds which become soft and friable on long exposure. At the base is a black, euxinic shale, 2-3½ feet thick, which contains small calcareous fossils. In the lower Broncks Lake, fossils are abundant, the most characteristic ones being large colonies of encrusting bryozoans and the brachiopod Dicoelosia varicus (Conrad). The large crinoid stems of Mariacrinus stoloniferous, Hall and the brachiopods Uncinulus abruptus, Hall, Rhipodomelloides oblata (Hall), and Kozlowskielina perlamellosua (Hall) are abundant. The lower Broncks Lake is 15 feet thick at Ravena and South Bethlehem, 14 feet at East Kingston and 16 feet at Catskill.

The upper Broncks Lake is a fine-grained, blue-gray limestone which differs lithologically from the lower part by 1) its more massive bedding (a few inches to a foot or more thick), 2) its argillareous material is less obvious, 3) the occurrence of one to three chert layers near its base, and 4) its characteristically pitted weathered surface. Faunally, the unit was observed to contain a few Dicoelosia and bryozoan whorls only in the lower 4 to 5 feet. Lingula rectilatera (Hall) is common but has not been observed in the lower Broncks Lake. Typical thicknesses in the Hudson Valley are: 25 to 30 feet at Ravena, 24 feet at South Bethlehem, 23 feet at Broncks Lake, and 27 feet at East Kingston.

New Scotland Formation

The term New Scotland was first applied by Clarke and Schuchert (1899, pp. 874-878) to the "Catskill or Delthyris shaly limestone" of early workers (Hall, 1893, pp. 8-13, Darton, 1894, pp. 406-407). Clarke and Schuchert probably included the Kalkberg Formation in their original definition of the New Scotland. Rickard (in press) and Dunn, et al., (unpublished) separate the Kalkberg and the New Scotland strata into two formations.

The New Scotland Formation consists primarily of alternating medium gray, sublithographic to fine grained, impure limestone, and dark gray calcareous mudstone with varying amounts of chert and pyrite. Toward the top of the New Scotland some of the limestone layers become similar to the Becraft Limestone as calcite crystals increase in size to medium and coarse grain. At all areas in the central Hudson Valley where the contact is exposed, the lowest New Scotland, in gross chemical composition, is not a limestone. Rather, it is primarily a calcareous mudstone or siltstone in which the total carbonate is 45% or less. The top of the New Scotland Formation is taken arbitrarily at the lowest appearance of green shale and the highest occurrence of typical fine-grained, gray New Scotland limestone. The change coincides with a sudden increase in lime content in the South Bethlehem, Alsen and Kingston areas.

Significant facies changes occur in the Hudson Valley area. At Ravena and South Bethlehem the New Scotland Formation is a calcareous mudstone throughout its entire thickness. At Broncks Lake only the upper 6 feet can be called a limestone. At East Kingston the New Scotland is

mostly limestone with but 27 feet at the base being argillaceous or silty. An additional change in the New Scotland Limestone is a notable increase in the content of silt in the Kingston area and a corresponding decrease in the alumina content. Judging from chemical analyses, the New Scotland Limestone is basically a limy siltstone or silty limestone at Kingston, but in the Albany area, although still silty, the clay content increases approximately by a factor of 2. According to Rickard (in press) the New Scotland formation also changes character to the west in the Schoharie and Canajoharie quadrangles. Here it is lower in clay content and gradually becomes more similar to the Kalkberg Formation.

Several valuable marker beds in the New Scotland have been noted in the central Hudson Valley, particularly in the South Bethlehem to Broncks Lake area. Plate I shows their position and gives a short description of their characteristics.

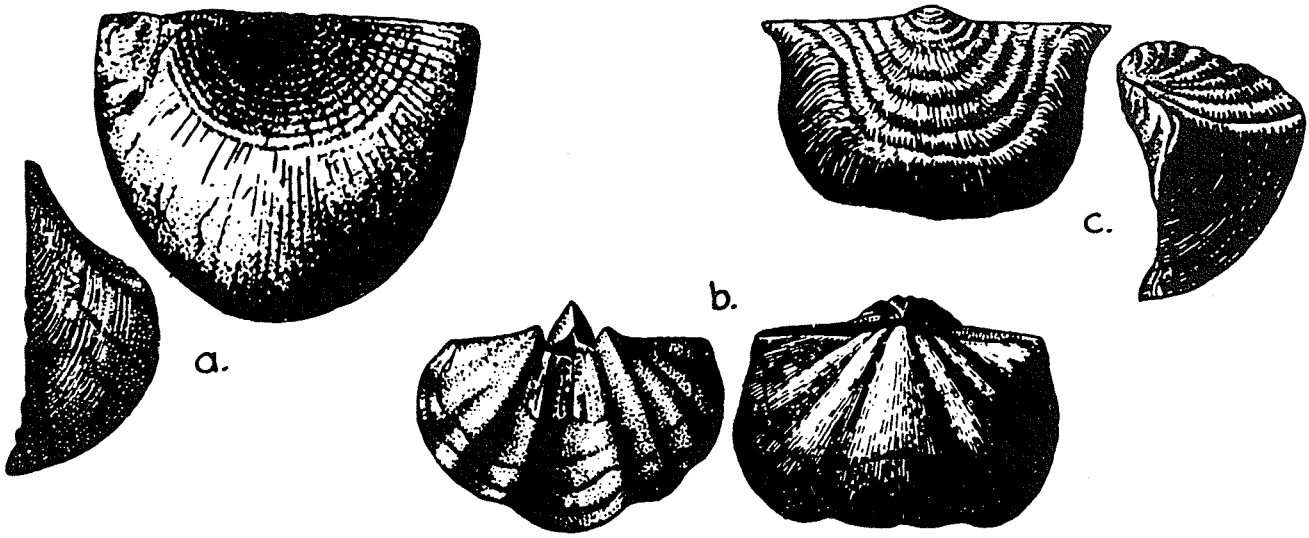
The brachiopods Kozlowskielina perlamellosa (Hall), Eospirifer macropleurus (Conrad), Leptaena "rhomboidalis" (Wilckens), Leptostrophia beckii (Hall), Howellella cycloptera (Hall), and Strophonella punctulifera (Conrad) are common. Bryozoans, trilobites, pelecypods, ostracods and platyceratid gastropods have also been noted. In all, over 300 species have been reported from the Kalkberg and New Scotland formations.

New New Scotland Formation is 65 feet thick (Rickard, in press) in the Helderbergs. Core data at South Bethlehem and Ravena indicate a thickness of 98 feet and approximately 92 feet is present at Broncks Lake. It is 98 feet thick at Austin's Glen (Rickard, in press), and about 100 feet at East Kingston.

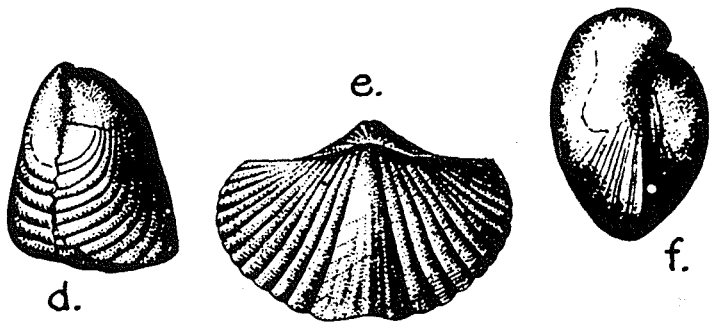
Becraft Formation

The name Becraft was given by Darton (1894) to the exposures of the coarse grained limestone occurring above the New Scotland Formation on Becraft Mountain near Hudson, New York. The Becraft Formation consists of very coarse-grained, light gray, tan, reddish, or nearly white limestone with green or gray shale partings. Locally chert occurs near the base and also near the top, and at Ravena minor quartz sandstone lenses have been observed near the top. It weathers to a light gray and is a prominent ledge former. Bedding planes are 3 to 6 inches apart at the base and over a foot apart in the upper portion. Appearance in outcrop is massive; bedding planes are irregular and difficult to see. The Becraft Formation has a thickness of 13 to 27 feet in the Albany area, 40 to 65 feet in the Ravena to Alsen area, and 35 to 50 feet in the Kingston area.

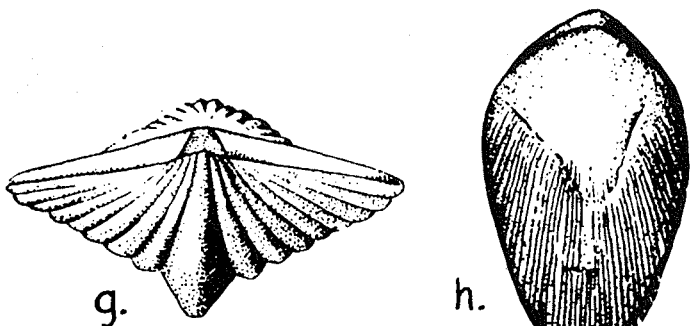
Fossils are abundant and crinoid stems are most common. The brachiopods Atrypa reticularis, (Linnaeus), Gypidula (?) pseudogaleata (Hall), Leptaena "rhomboidalis" (Wilckens), Meristella princeps (Hall), Schizophoria multistriata (Hall), "Spirifer" concinnus (Hall), and Howellella cycloptera (Hall) are among the most common.



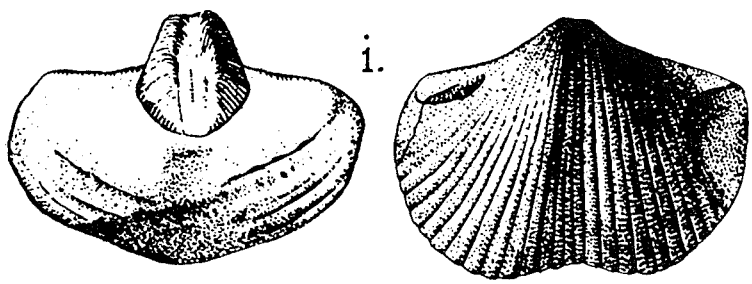
NEW SCOTLAND BEDS FOSSILS: a. Strophonella leavenworthana, x 1⅛.
b. "S" (Eospirifer) macropleura, x ¾. c. Leptaena rhomboidalis, x ¾.



BECRAFT LIMESTONE FOSSILS:
d. Uncinulus campbellanus, x1⅛.
e. "Spirifer" concinnus, x 1⅛.
f. Gypidula pseudogaleata, x1⅛.



GLENERIE LIMESTONE FOSSILS:
g. "S." murchisoni, x 1⅛.
h. Rensselaeria ovoides, x ¾.
i. "Spirifer" arenosus, x ¾.



Alsen Formation

The Alsen Formation was named by Grabau (1919). He gave the name to cherty limestones which lie above the Becraft Formation in the central Hudson Valley. The Alsen Formation, in the Ravena-South Bethlehem area, and the Port Ewen Formation (above the Alsen) from the Catskill area south are the youngest formations of the Helderbergian Series.

The Alsen is a medium-grained, medium to dark gray, cherty limestone with interbedded argillaceous material. It is similar in appearance to the lower Hannacroix Member of the Kalkberg Formation. Aside from its stratigraphic position, the Alsen differs from the Kalkberg in having fewer layers of chert, being somewhat coarser grained, and containing Spirifer concinnus and Monotrypa tabulata. According to Rickard (in press) the Alsen is absent from the Coxsackie quadrangle to West Berne (northwest). Rickard measured 24 feet in the Broncks Lake section, 35 feet at Austin's Glen, and 20 feet in the Kingston area. Core data from East Kingston also indicate a 20 foot thickness for the Alsen in that area. At Ravena, however, some confusion exists in some cores where Alsen-like limestone is present beneath Glenerie quartzite (Oriskany) along with massive chert of uncertain identity. The limestone might reasonably be Alsen. The chert could be Alsen, Port Ewen or Glenerie.

Glenerie Formation

The name Oriskany Sandstone was applied by Vanuxem (1937) to a nearly pure, fossiliferous quartz sandstone exposed at Oriskany Falls in east-central New York. This sandstone is represented in the Hudson Valley by cherts and siliceous limestones containing Oriskany fossils, for which Chadwick (1908, p. 348) proposed the name Glenerie. The Glenerie varies in thickness throughout the Hudson Valley from less than 5 to over 50 feet, generally thickening to the south. Its fossils are usually silicified and many excellent collections have been made from these beds. The most common brachiopods are: Eatonia peculiaris (Conrad), Hipparionyx proximus (Vanuxem) Leptocoelia flabellites (Conrad), Leptostrophia oriskania (Clarke), Rensselaeria ovoides (Eaton), Costispirifer arenosus (Conrad), and Acrospirifer murchisoni (Castelnau). The trilobites: Homalonotus vanuxemi (Hall), Phacops logani (Hall) and Synphoria stemmata (Clarke) have also been found.

Esopus Formation

The Esopus Shale or Grit, overlying the Glenerie Formation, is the "Caudagalli grit" of Vanuxem (1842) and other early workers, so called from the markings Taonurus cauda-galli (Vanuxem) on the bedding planes which resemble a rooster's tail. The Esopus, because of its soft, argillaceous nature forms gentle slopes between the terraces maintained by the Becraft-Glenerie below and the Schoharie-Onondaga above. It is relatively barren of fossils except for a few brachiopods and the Taonurus markings whose origin is disputed. Taonurus has been described as a worm burrow, "fucoid", or seaweed or wave-mark of a peculiar type. Recently Laskowski (1956) has submitted evidence that these markings represent plant remains. The Esopus is about 150 feet thick in the Coxsackie quadrangle and will be seen at Stop 3.

Schoharie Formation

This formation, the youngest of the Lower Devonian units recognized in eastern New York, has been subdivided into several members. The lower 20-30 feet, known as the Carlisle Center Member, consists of laminated and flaggy calcareous mudstones or siltstones with a sparse fauna. The overlying Leeds Member is about 25 feet thick. It is composed of calcareous mudstones and siltstones which grade upward into cherty, argillaceous limestones, weathering buff. Fossils are more common in the Leeds Member. The most common Schoharie fossils are the brachiopods: Atrypa impressa (Hall), Chonetes hemisphericus (Hall), Elytha fimbriata (Conrad), Leptaena "rhomboidalis" (Wilckens), "Spirifer" macrus (Hall), "S." raricosta (Conrad); the trilobite: Synphoria anchiops (Hall) and various gastropods, cephalopods, corals and conularids.

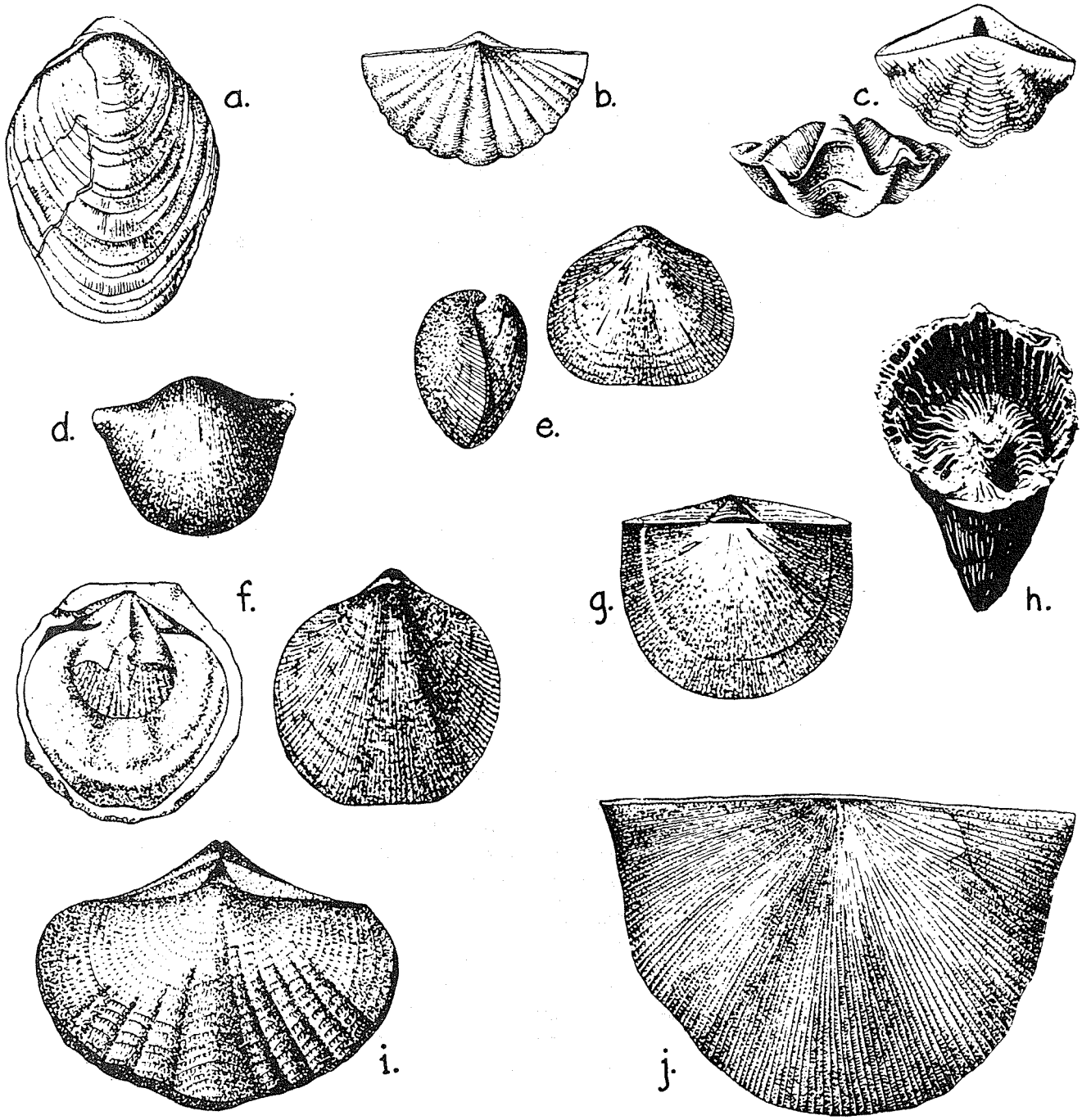
MIDDLE DEVONIAN

Onondaga Limestone and Albrights Reef

The Onondaga Limestone of the Hudson River Valley, approximately 100 feet thick, consists of gray, fossiliferous limestones, often cherty. At two localities in the Coxsackie quadrangle coral reefs have been recognized, one of which will be visited on this trip (Stop 5). Oliver (1954),(1956 a) has subdivided the Onondaga into four members: in ascending order, the Edgecliff, Nedrow, Morehouse and Seneca. Only the lower three are present in the Coxsackie area, the Seneca having been replaced by the overlying Bakoven Black Shale and Stony Hollow Sandstone.

The basal contact of the Onondaga (Edgecliff Member) with the underlying Schoharie is gradational. The Edgecliff (35-40 feet) is characterized by abundant white-weathering chert and a profusion of both rugose and tabulate corals in addition to brachiopods and other fossils. It consists of light gray coarse-grained crinoidal limestone in beds $\frac{1}{2}$ to 3 feet thick. Lithologic separation of the Nedrow Member (20 feet) in the Hudson Valley is not so distinct as further west but its characteristic platyceratid gastropods persist. The remainder of the Onondaga is referred to the Morehouse Member, approximately 50 feet thick, which contains a middle cherty division between upper and lower non-cherty divisions. Morehouse beds consists of finer grained limestones than the Edgecliff and the chert usually is black. Fossils are abundant.

The Albrights reef (Stop 5) forms hills on both sides of the road one mile west-southwest of Albrights. It is approximately 1000 feet long, 250 feet wide and over 20 feet high (Oliver 1956 b). Tabulate and colonial rugose corals are abundant in the very coarse-grained pink or gray limestone which lacks distinct bedding. Fossils present are the corals: Cyathophyllum sp., Cystiphyllum sp., Favosites sp., Streptelasma sp., Synaptophyllum sp., and Zaphrentis sp.; the brachiopods: Amphigenia elongata (Vanuxem), Atrypa "reticularis" (Linnaeus), Coelospira camilla (Hall), Leptaena "rhomboidalis" (Wilckens), "Spirifer" divaricatus (Hall), "S." macrus (Hall), Stropheodonta concava (Hall), and Strophonella ampla (Hall); and the trilobites: Odontocephalus selenurus (Eaton), Phacops cristata (Hall), and Synphoria anchiops (Hall).



SCHOHARIE AND ONONDAGA LIMESTONE FOSSILS:

a. Amphigenia elongata, ×¾. b. "Spirifer" duodenarius, × 1¼.
c. "Spirifer" raricosta, ×1¼. d. Chonetes hemisphericus, × 1¼.
e. Schizophoria propinqua, ×1¼. f. Atrypa impressa, × 1¼.
g. Schuchertella pandora, ×1¼. h. Zaphrentis prolifica, × ¾.
i. Elytha fimbriata, ×1½. j. Strophonella ampla, × 1¼.

Hamilton Group

The highest beds to be seen on this trip are those of the Hamilton shales and sandstones. In the Coxsackie quadrangle this group is divided into 5 members: in ascending order, the Bakoven, Stony Hollow, Mount Marion, Ashokan, and Kiskatom. Over 2000 feet of Hamilton beds are present. The top occurs in the adjacent Durham quadrangle to the west where an additional 1000 feet of Hamilton beds (entirely Kiskatom) are found. The Bakoven, Stony Hollow and Mount Marion members are chronological equivalents of the Marcellus Formation of the Hamilton in central and western New York. The Ashokan and Kiskatom are non-marine rocks representing the Skaneateles, Ludlowville and Moscow Formations.

Overlying the Onondaga Limestone with a sharp but apparently conformable contact are the black shales of the lower Hamilton, the Bakoven Member. These shales, 180-200 feet thick, contain a small fauna of brachiopods, pelecypods, cephalopods and "pteropods" typical of Devonian black shales elsewhere in New York. The Bakoven is a continuation of the Union Springs Black Shale of central New York. It is overlain by the Stony Hollow Sandstone Member, approximately 100 feet thick, which contains a few brachiopods, corals, and trilobites, but apparently none of the cephalopods so characteristic of its equivalent to the west, the Cherry Valley ("Agoniatite") Limestone. Both the Bakoven and Stony Hollow are chronological equivalents of the Seneca Member of the Onondaga Limestone in western New York. Inasmuch as no good exposures suitable for a large group have been located, the Bakoven and Stony Hollow will not be seen on this trip. The fauna consists of the brachiopods: Chonetes cf. mucronatus (Hall), Leiorhynchus limitare (Vanuxem), L. mysa (Hall), and Nucleospira concinna (Hall); the pelecypods: Lunulicardium marcellanse (Vanuxem)and Pterochaenia fragilis (Hall); and Styliolina fissurella (Hall), and Tornoceras (Parodoceras) discoideum (Conrad).

The remainder of the marine portion of the Hamilton Group in the Coxsackie area is known as the Mount Marion Member. These interbedded bluish-gray, sandy shales and argillaceous siltstones, 1200 feet thick, contain pebble beds, crossbedding and flow rolls in the upper portion near the transition into the overlying non-marine Ashokan flags. Fossils of brachiopods, pelecypods, and cephalopods, are abundant and usually occur as molds, both internal and external. Several good exposures are located in the vicinity of the Alcove Reservoir (Stops 4A and 4B).

Common Mt. Marion fossils are the following:

Brachiopods

Athyris cora (Hall)
Atrypa spinosa (Hall)
Camarotoechia congregata (Conrad)
C. prolifica (Hall)
C. sappho (Hall)
Chonetes coronatus (Conrad)
Leptostrophia perplana (Conrad)
Schizophoria cf. striatula (Schlotheim)
Paraspirifer acuminatus (Conrad)
Brachyspirifer audaculus (Conrad)
Mucrospirifer mucronatus (Conrad)
Tropidoleptus carinatus (Conrad)

Of Uncertain Affinity

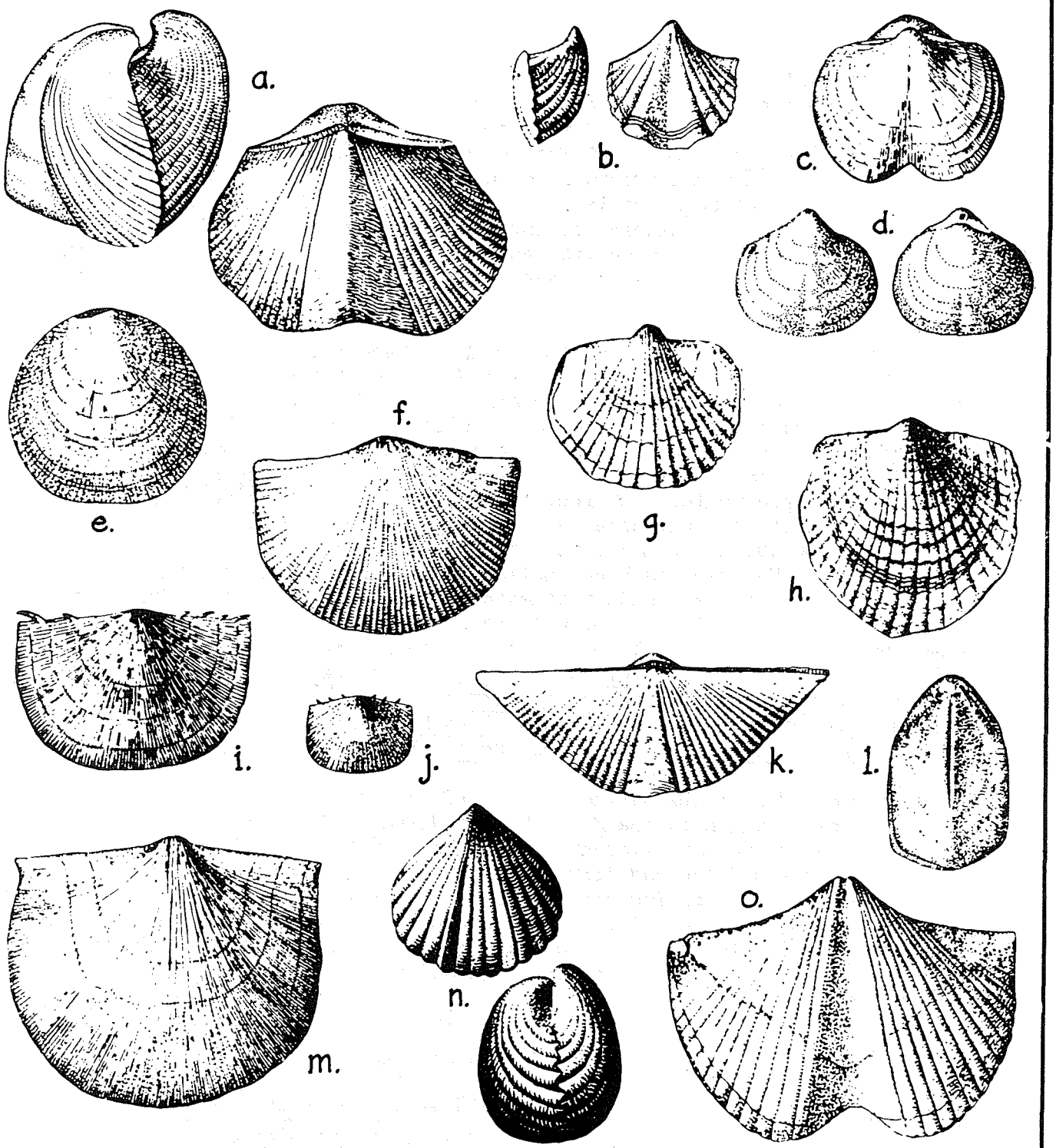
Tentaculites bellulus (Hall)

Pelecypods

Actinodesma erectum (Conrad)
Actinopteria boydi (Conrad)
Cypricardella complanata (Hall)
Goniophora hamiltonensis (Hall)
Grammysia bisulcata (Conrad)
Modiomorpha concentrica (Conrad)
Nucula bellistriata (Conrad)
Nyassa arguta (Hall)
Orthonata undulata (Conrad)
Paracyclus lirata (Conrad)

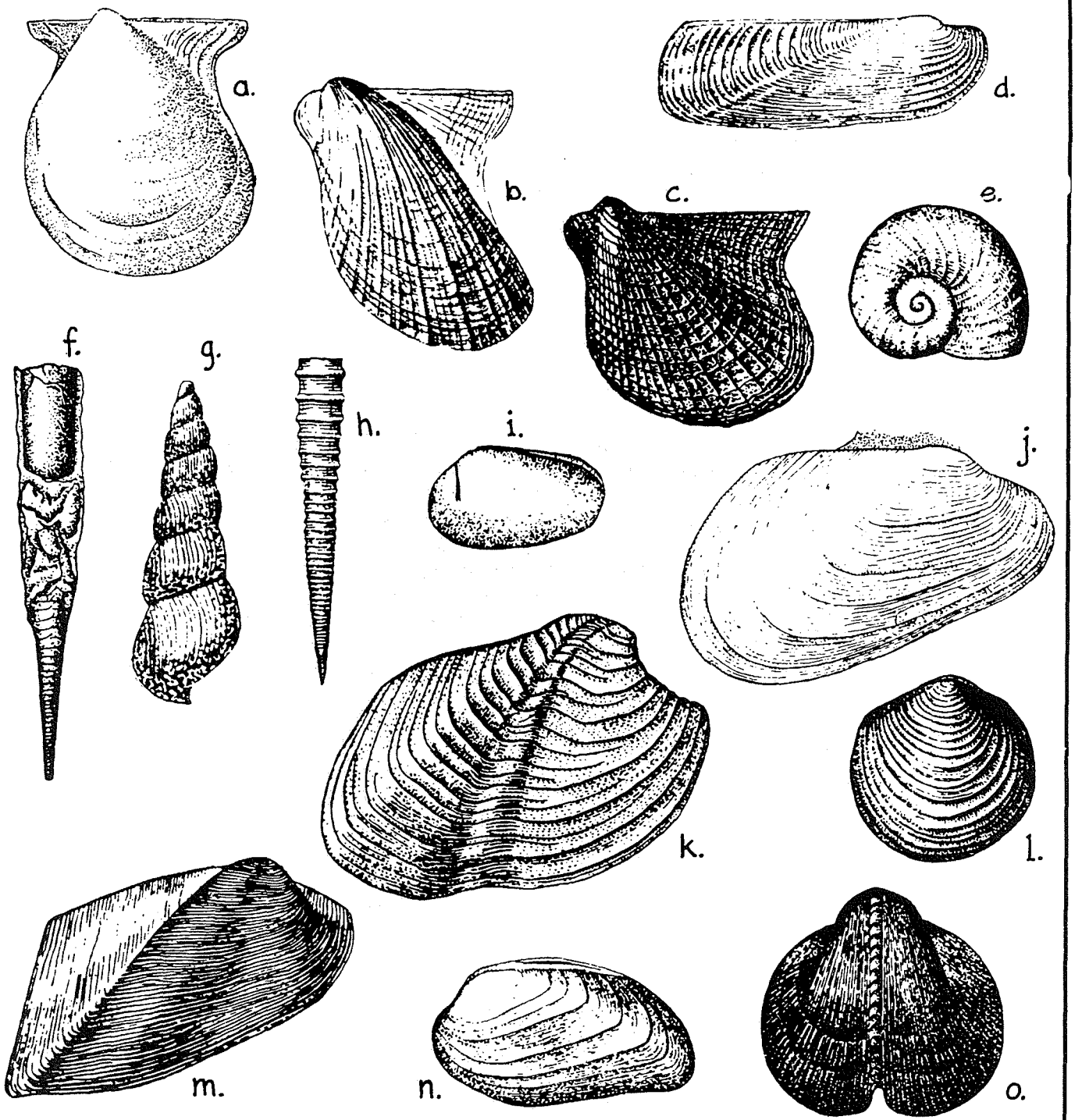
Trilobites

Greenops boothi (Green)
Homalonotus dekayi (Green)



MOUNT MARION BEDS BRACHIOPODS:

a. "Spirifer" (Paraspirifer) acuminatus, x1½. b. Cyrtina hamiltonensis, x1½. c. Schizophoria striatula, x1¼. d. Athyris cora, x1½. e. Rhipidomella vanuxemi, x1½. f. Stropheodonta inaequiradiata, x1¼. g. Tropidoleptus carinatus, x1¼. H. Atrypa spinosa, x1¼. i. Chonetes coronatus, x1¼. j. Chonetes scitulus, x1¼. k. "Spirifer" (Mucrospirifer) mucronatus, x1¼. l. Dignomia alveata, x1¼. m. Stropheodonta demissa, x1¼. n. Camarotoechia congregata, x1½. o. "Spirifer" (Spinocyrtia) granulosus, x1¼.



MOUNT MARION BEDS FOSSILS:
a. Glyptodesma (Actinodesma) erectum, x ¾. b. Cornellites ["Pterinea"] flabellum, x ¾. c. Actinopteria boydi, x 1¼. d. Orthonota undulata, x ¾. e. Diaphorostoma lineatum, x 1¼. f. Michelinoceras ? [Orthoceras] subulatum, x ¾. g. Loxonema hamiltonensis, x 1½. h. Tentaculites bellulus, x 1½. i. Nuculites oblongatus, x 1¼. j. Modiomorpha mytiloides, x ¾. k. Grammysia bisulcata, x 1¼. l. Paracyclas lirata, x 1¼. m. Goniophora hamiltonensis, x 1¼. n. Nyassa arguta, x 1¼. o. Bucanopsis lyra, x 1½.

The greater portion of the Hamilton beds of this area consists of non-marine strata. These beds are unfossiliferous, except for small crustaceans and plant remains. The lower 300 feet, the Ashokan, contains laminated "bluestones" (sandstones) formerly extensively quarried for flagstones used in sidewalks and building construction. The interbedded shales are olive, weathering reddish or brown. The upper portion is known as the Kiskatom Member. This member consists of about 1500 feet of alternating red and green, green or gray sandstones. Cross-bedding, pebble layers and flow rolls occur. Fossils are rare - plant fragments are most common. Neither Ashokan nor Kiskatom beds will be seen on this trip.

STRUCTURE

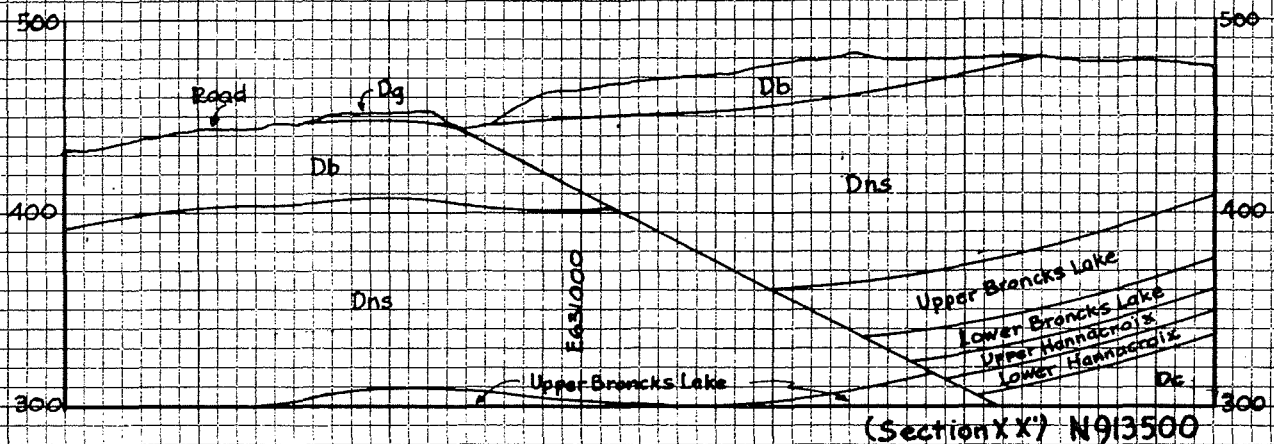
STRUCTURES IN THE WESTERN CENTRAL HUDSON VALLEY

The Silurian and Devonian formations lie unconformably on Ordovician graywackes, siltstones and shales which have undergone deformation varying from gentle warps to isoclinal folding. West of the Hudson River, these younger formations are strongly folded and thrust faulted. The faults and folds trend approximately north-south and the thrust faults usually dip from 20° to 35° eastward. Normal faulting is rare although the outcrop pattern caused by thrust faulting may locally seem to be caused by normal faults. Folding is most intense in the Kingston area. Northward the structures are similar but have a less violent aspect. Westward from the Hudson Valley the amplitude of the folding decreases and the faulting becomes less common.

Typical Hudson Valley fold-fault structures in the Silurian-Devonian strata consist of an anticline thrust over a syncline so that in plan two anticlines are adjacent to each other. In some cases the hidden synclinal structure may be very large, but the size of the hidden structure is rarely decipherable from the surface evidence. Plate II shows two typical structures in the Ravena area. Note that the lower and more southern structure gave little surface evidence of the syncline which was detected by core drilling.

ECONOMIC GEOLOGY

For the past two to three years the economics of industrial rock materials has been undergoing revolutionary changes in the central Hudson Valley. The changes are of major significance to producers of portland cement and lightweight aggregate in the whole eastern United States. In addition, new concepts of the quality of some limestones are of considerable importance in the quarrying and use of coarse aggregate. An indication of the scale of these changes in the raw material situation in the Hudson Valley may be seen in the increase of crushed stone reserves by a factor of about 3 to 5, the cement reserves by a factor of about 5 to 10 and the lightweight aggregate reserves from negligible to over a billion tons. Translated into monetary value this is the equivalent of finding a mining camp of the scale of Butte, Montana. All of these changes are based to a large extent upon systematic geologic studies of the nature and uses of rock raw materials and demonstrate clearly the value of geologists in this field.



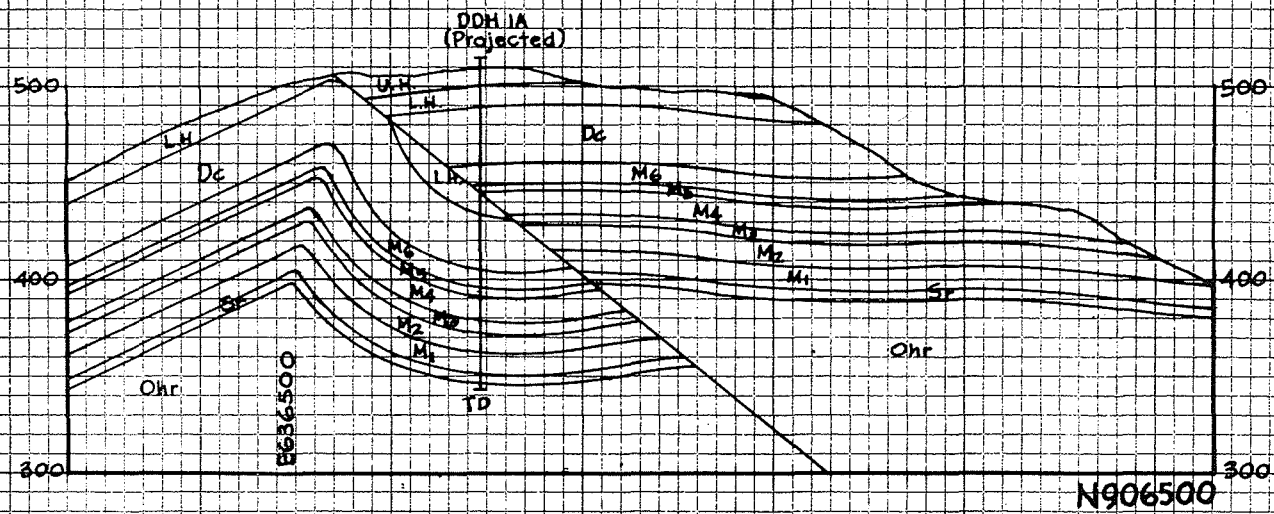


PLATE II C

TYPICAL HUDSON VALLEY-TYPE FOLD-THRUST FAULT STRUCTURES IN THE RAVENA AREA

SECTION N913500 (XX') is across the center on the right sheet of Plate III. The estimate of the amount of Becraft Limestone caught under the thrust fault is a minimum.

SECTION N906500 is a core-drilled structure southeast of Section N913500. Note that the size of the syncline under the thrust fault is not decipherable from surface outcrops. The stratigraphic relationships at the surface actually suggest normal faulting.

Scale 1" = 100'

The most significant new discoveries are that at least locally the New Scotland, Port Ewen, and Glenerie formations are suitable for coarse aggregate in concrete, and that the Esopus formation, at least locally, is suitable for expanded lightweight aggregate. In addition, careful analytical work, stratigraphically controlled, has resulted in methods of blending rock strata which are new in the Hudson Valley.

The Hudson Valley is uniquely situated for the economic production of raw materials in that it combines excellent transportation facilities (water, air, rail, highway) with one of the world's largest metropolitan markets. The value of any raw material produced in the Hudson Valley is likely to be considerably enhanced over less favorably situated occurrences of the same material.

Portland cement plants have long been established just south of Catskill and at Becraft Mountain southeast of Hudson, and natural cement has been produced in the Rosendale-Kingston area for many years. Coarse aggregate producers have operated at Kingston, at Hudson, west of Catskill, and at South Bethlehem for a considerable time.

Within the past few years the following companies have either announced the construction of new plants or have already begun operation: Hudson Cement Company at East Kingston, in operation; Southern Lightweight Aggregate Company just south of Saugerties, plant to be constructed: Atlantic Cement Company, Ravena (jointly owned by Newmont Mining Company and the Cerro Corporation), plant to be constructed. Extensive optioning and current drilling immediately southwest of Kingston indicate still more activity within the Hudson Valley.

The operation of the Hudson Cement Company at East Kingston is based on new concepts of utilization of rock strata in the Hudson Valley. Quarrying procedures involve the blending of various rock types to produce portland cement, and the selective quarrying of other rock types to produce coarse aggregate. The structures in the area are complex. The normal Hudson Valley folding and thrust faulting is abnormally severe and large areas of overturned and steeply dipping beds occur. The planning and execution of the drilling, the determination of reserves of various categories of rock, the chemical and physical testing of the rock, and the day-to-day development of the quarrying operation all require geologic control. The basis for all phases of operation is a detailed geologic outcrop map and vertical cross-sections which are at a scale of 100 feet to the inch, with 5 foot contour interval.

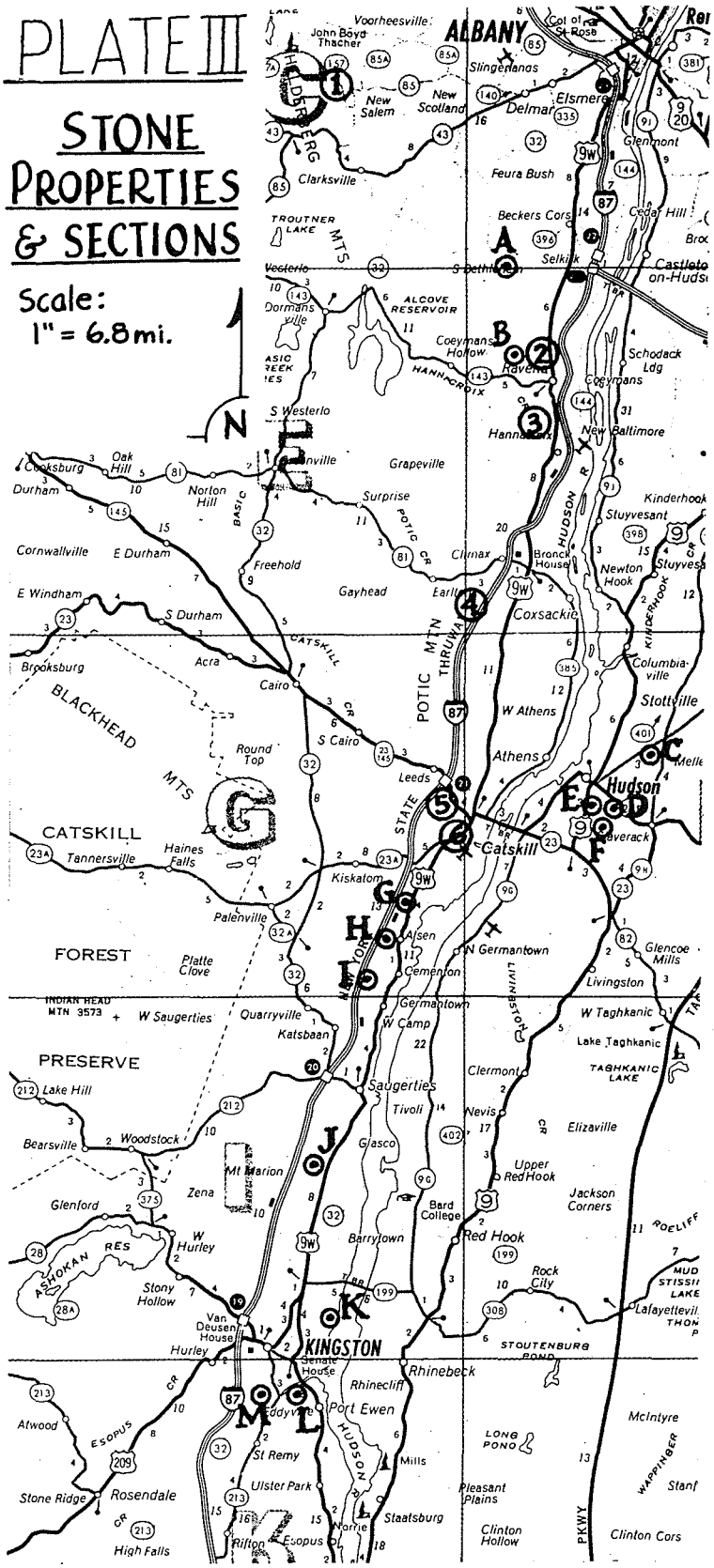
The operation of the Callanan Road Improvement Company at Kingston and South Bethlehem and the projected operation of the Atlantic Cement Company are, so far as the quarrying is concerned, based on similar detailed geologic data.

The Southern Lightweight Aggregate Company at Mt. Marion, just south of Saugerties, will quarry shales of the Esopus formation. This rock, when heated to the proper temperature, expands to a scoriaceous material which makes excellent aggregate for lightweight cement blocks. Considerably more activity in lightweight aggregate exploration is occurring throughout the valley.

PLATE III

STONE PROPERTIES & SECTIONS

Scale: 1" = 6.8 mi.



QUARRIES AND CURRENT PROSPECTS

A. Callanan Road Improvement Co.
B. Atlantic Cement Co. - to be constructed.
C. Catskill Mountain Stone Co. - crushed stone.
D. Lone Star Cement Co.
E. Universal Atlas Cement Co.
F. Colarusso and Sons - crushed stone.
G. North American Cement Corp.
H. Lehigh Portland Cement Co.
I. Alpha Portland Cement Co.
J. Southern Lightweight Aggregate Co. - to be constructed.
K. Hudson Cement Co.
L. Callanan Road Improvement Co.
M. New York Trap Rock Co. - prospect. Product uncertain.

STRATIGRAPHIC SECTIONS

① John Boyd Thacher Park
Db - Dns - Dk - Dg - Dm - Sr

② Blenis hair pin curve quarry
Dc - Dm

③ Hannacroix Creek (Deans Mills area) Dk - Dc - Dm - Sr

④ Broncks Lake
Da - Db - Dns - Dk - Dc

⑤ Austin's Glen
Db - Dns - Dk - Dc - Dm

⑥ Quarry Hill
Dk - Dc - Dm

USES OF ROCK FORMATIONS IN THE CENTRAL HUDSON VALLEY

Principal Formations and Lithologies	Potential Uses
Onondaga limestone	Coarse aggregate, portland cement, locally agricultural lime and blast furnace flux.
Schoharie sandy limestone	None known
Esopus silty shale	Lightweight aggregate
Glenerie impure limestone	Coarse aggregate, portland cement*
Port Ewen impure limestone	Coarse aggregate, portland cement*
Alsen impure limestone	Coarse aggregate, portland cement*
Becraft limestone	Coarse aggregate, portland cement* agricultural lime
New Scotland silty limestone and limey siltstone	Coarse aggregate, portland cement*
Kalkberg impure limestone	Coarse aggregate, portland cement*
Coeymans limestone	Portland cement, coarse aggregate
Manlius limestone	Portland cement, agricultural lime, blast furnace flux, coarse aggregate.
Rondout magnesium limestone	Natural cement.

*Mixed with purer limestones such as Becraft, Coeymans, or Manlius

It is interesting to note that in the Kingston area the total potentially economic rock section is about 800 feet thick.

REFERENCES

Chadwick, G. H. (1908), Revision of "the New York series". Science n.s., 28; 346-48

_____ (1944), Geology of the Catskill and Kaaterskill quadrangles: N. Y. S. Museum Bull. No. 336.

Clarke, J. M. and Schuchert, Charles (1899), The nomenclature of the New York series of geological formations: Science, n.s. 10: 874-78.

Darton, N. H. (1894), Report on the relations of the Helderberg limestones and associated formations in eastern New York: N.Y. State Geol. Rep't., 13: 199-228.

Dunn, J. R., Cutcliffe, W.E. and LaBrake, R., Kalkberg and New Scotland stratigraphy of the Central Hudson Valley, unpublished.

Goldring, Winifred (1935), Geology of the Berne quadrangle: N. Y. State Museum Bull. 303: 238 p., 72 fig.

_____ (1943), Geology of the Coxsackie quadrangle, New York: N. Y. State Museum Bull. 332.

Grabau, A. W. (1919), Significance of the Sherburne Sandstone in Upper Devonic stratigraphy: Geol. Soc. Amer. Bull. v. 30 p. 423-70.

Hall, James (1893), An introduction to the study of the genera of Paleozoic brachiopoda: Natural History of New York, Paleontology 8. pt. 1, 367 p., 44pl.; pt. 2 394 p., 64 pl.

Hartnagel, C. A. (1912), Classification of the geologic formations of New York, N.Y. State Museum Handbook 19.2 nd. ed. 99p.

Johnsen, J. H. (1958), Preliminary report on the limestone of Albany County, New York. N. Y. State Museum and Sci. Serv., 43 pp.

Laskowski, E. (1956), Sedimentary petrology and petrography of the Esopus, Carlisle Center and Schoharie Formations (Lower Devonian) in New York State with a discussion of the Taonurus problem: Masters Thesis, R. P.I.

Oliver, W. A., Jr. (1956a), Stratigraphy of the Onondaga Limestone in eastern New York: Geol. Soc. Amer. Bull. vol. 67 pp. 1441-1474.

_____ (1956b), Biostromes and bioherms of the Onondaga Limestone in eastern New York: N. Y. State Museum Circ. 45.

Rickard, L. V.,Late Cayugan (Upper Silurian) and Helderbergian (Lower Devonian) stratigraphy in New York: N. Y. State Museum Bull. (in press).

Ruedemann, Rudolph (1930), Geology of the Capital District: N. Y. State Museum Bull. 285, 218 p., 40 fig., 39 pl.

Smith, Burnett (1929), Influence of erosion intervals on the Manlius-Helderberg series of Onondaga County, New York: N. Y. State Museum Bull., 281, p. 25-36.

Vanuxem, Lardner (1842), Geology of New York. Part 3, comprising the survey of the third geological district: (Nat. Hist., pt. 3) V. 1. 306 p.

TRIP STOPS

Stop 1A. Callanan Road Improvement Company Quarry, northeastern part.

Outcrop has Normanskill shales, siltstones, and graywackes at the base, overlain by the full thickness of the Rondout Formation and 12 feet of the Manlius Formation. All units are essentially conformable even though they are of Ordovician, Silurian (?) and Devonian ages. Of particular interest are the abundant Tentaculites in the lower unit of the Manlius Formation and the transparent obtuse rhombohedrons of calcite associated with quartz crystals in the Rondout Formation.

Stop 1B. Callanan Road Improvement Company Quarry, center.

The walls of the quarry have typical Hudson Valley thrust fault structures. The Rondout, Manlius, Coeymans and part of the Kalkberg formations are exposed in the walls of the quarry. Plate VI is a picture of the quarry, looking south, in which the faults and formations are indicated.

Stop 2. Synclinal structure 4500 feet south-southeast of the Callanan Road Improvement Company quarry.

New Scotland Limestone, Becraft Limestone, Glenerie Sandstone and Chert (Oriskany) and Esopus Shale are exposed. The Becraft Formation is thrust over the Glenerie Formation at the east side of the structure, and a zone of cleavage and shear in the Becraft branches north-northwestward from the thrust fault. Plate V is a map of the area and Plate II shows a cross-section through the structure which was core drilled about 10,000 feet southeast of Stop 2.

Stop 3. An exposure of the Esopus Formation in a cliff.

The Glenerie Formation and the Becraft Formation are exposed at the base.

Stop 4A. Mt. Marion beds, lower part.

The exposure is in an old quarry from which flagstone was produced. Brachiopods and Tentaculites are abundant.

Stop 4B. Mt. Marion Sandstone, upper part.

The exposures are in a quarry from which flagstone was produced. Lack of marine fossils and the fairly common plant remains suggest non-marine origin.

Stop 5. Onondaga Reef.

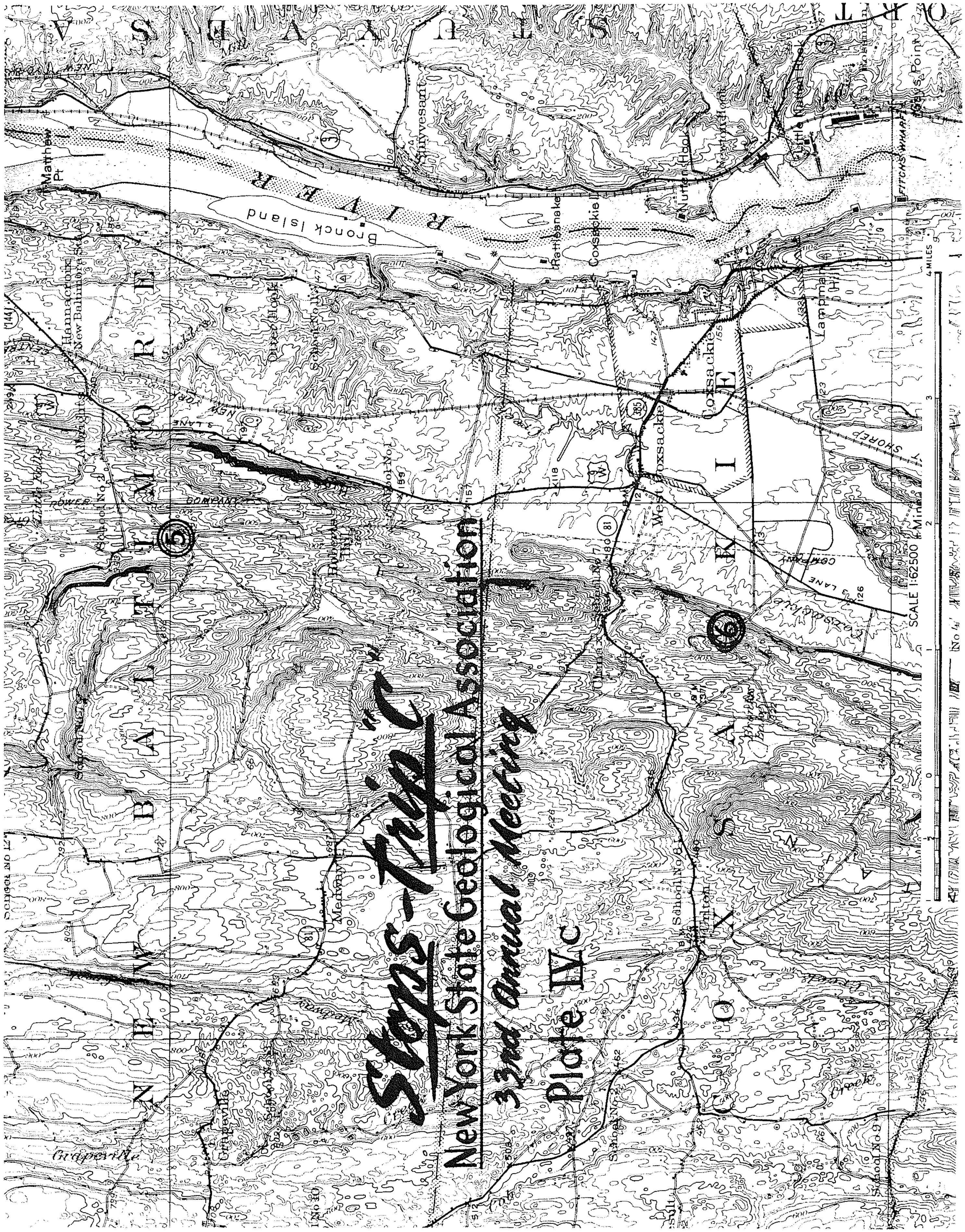
This is one of the reefs which is typical of the Onondaga Formation in New York. Fossil collecting is excellent.

Stop 6. Broncks Lake stratigraphic section.

All units of the Kalkberg Formation are exposed but not fully. All of the New Scotland and Becraft Formations can be seen, and 24 feet of the Alsen Formation is visible. The strata dip steeply westward and are cut by a fault which repeats part of the Kalkberg Formation.

NOTES ON TRIP C


Lower
Schodack Island
Houghtaling Island
Upper Schodack I
Mull I
Barren Island
RENSSELAER CO
ALBANY CO
Schermerhorn
Castleton-on-Hudson
Selkirk
Beaver Dam
CASTLETON CUTOFF
SHORE
WEST
3 LANE
ADIRONDACK
LUNCH
Ravena
Bethlehem Heights
South Bethlehem
Callanans Corners
Coeymans Hollow
Hollow
Creek
Coeymans
1A
1B
2
3
4A
4B


"Stops" - Trip C
New York State Geological Association
33rd Annual Meeting
Plate IV c
SCALE 1:62500
4 MILES
Bronck Island
Coxsackie
West Coxsackie
Stuyvesant
Nutten Hook
Rattlesnake
New Baltimore
Hannacroix
Medway
Grapeville
Little Nutten Hook
Stuyvesant Falls
Lampman Hill

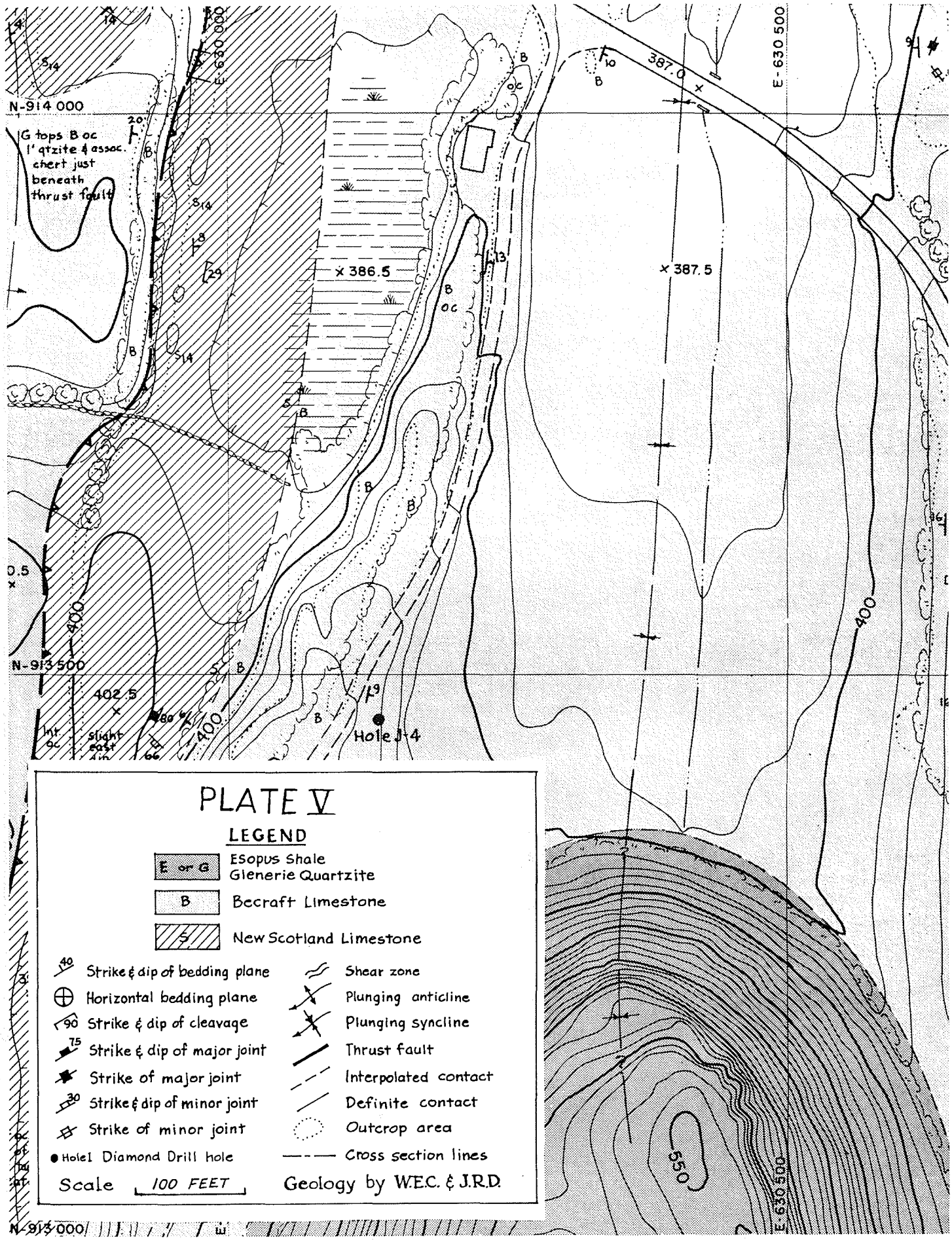


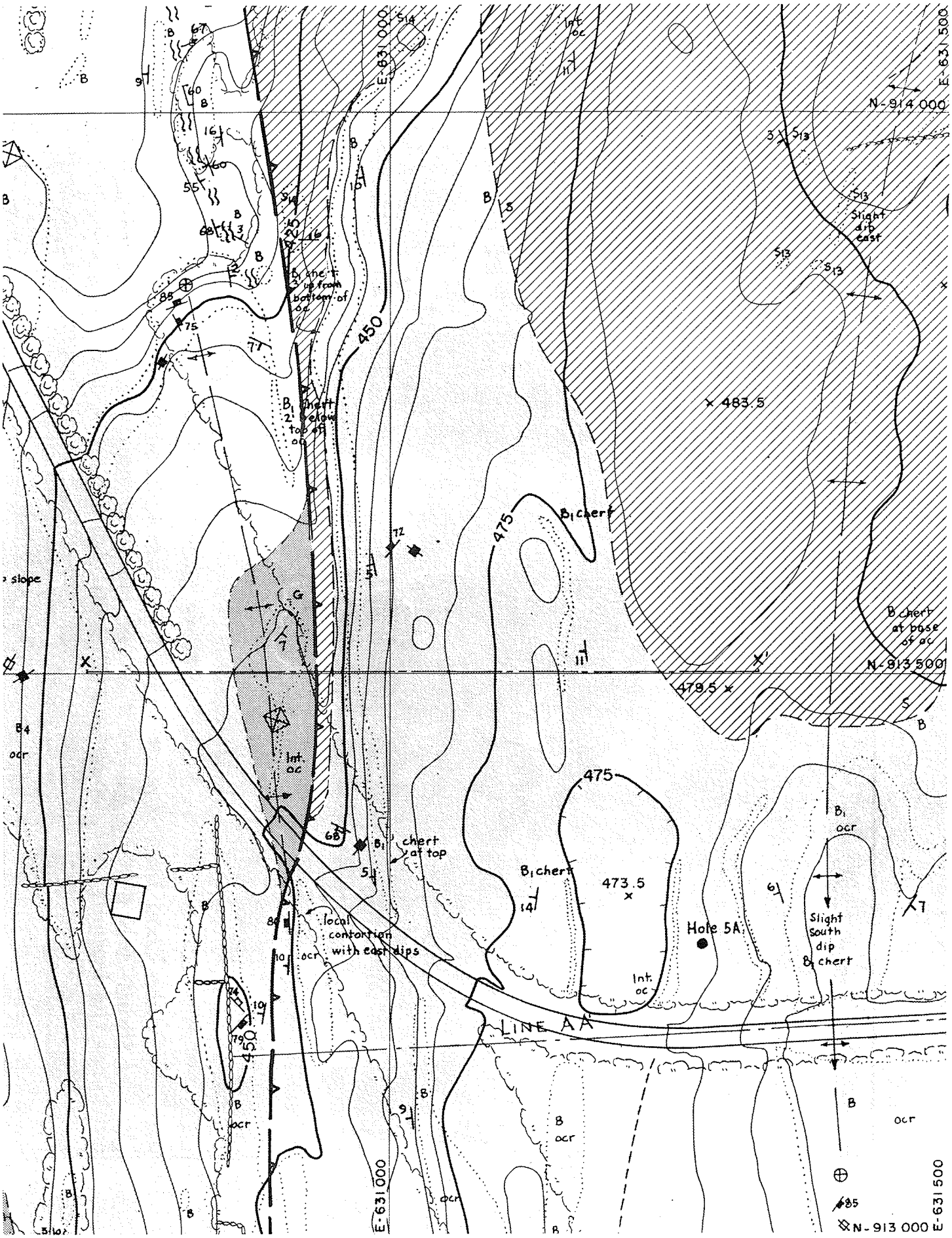
PLATE V

LEGEND

- E or G — Esopus Shale / Glenerie Quartzite
- B — Becraft Limestone
- S — New Scotland Limestone
- Strike & dip of bedding plane
- Horizontal bedding plane
- Strike & dip of cleavage
- Strike & dip of major joint
- Strike of major joint
- Strike & dip of minor joint
- Strike of minor joint
- Hole1 Diamond Drill Hole
- Shear zone
- Plunging anticline
- Plunging syncline
- Thrust fault
- Interpolated contact
- Definite contact
- Outcrop area
- Cross section lines

Scale 100 FEET

Geology by W.E.C. & J.R.D.


E-631 000
E-631 500
N-914 000
N-913 500
N-913 000
450
475
475
483.5
479.5
473.5
Hole 5A
LINE AA
B chert at base of oc
B₁ chert 2' below top of oc
B₁ chert at top
B₁ chert
B₁ ocr
Slight dip east
Slight south dip B₁ chert
local contortion with east dips
Int. oc
ocr
slope

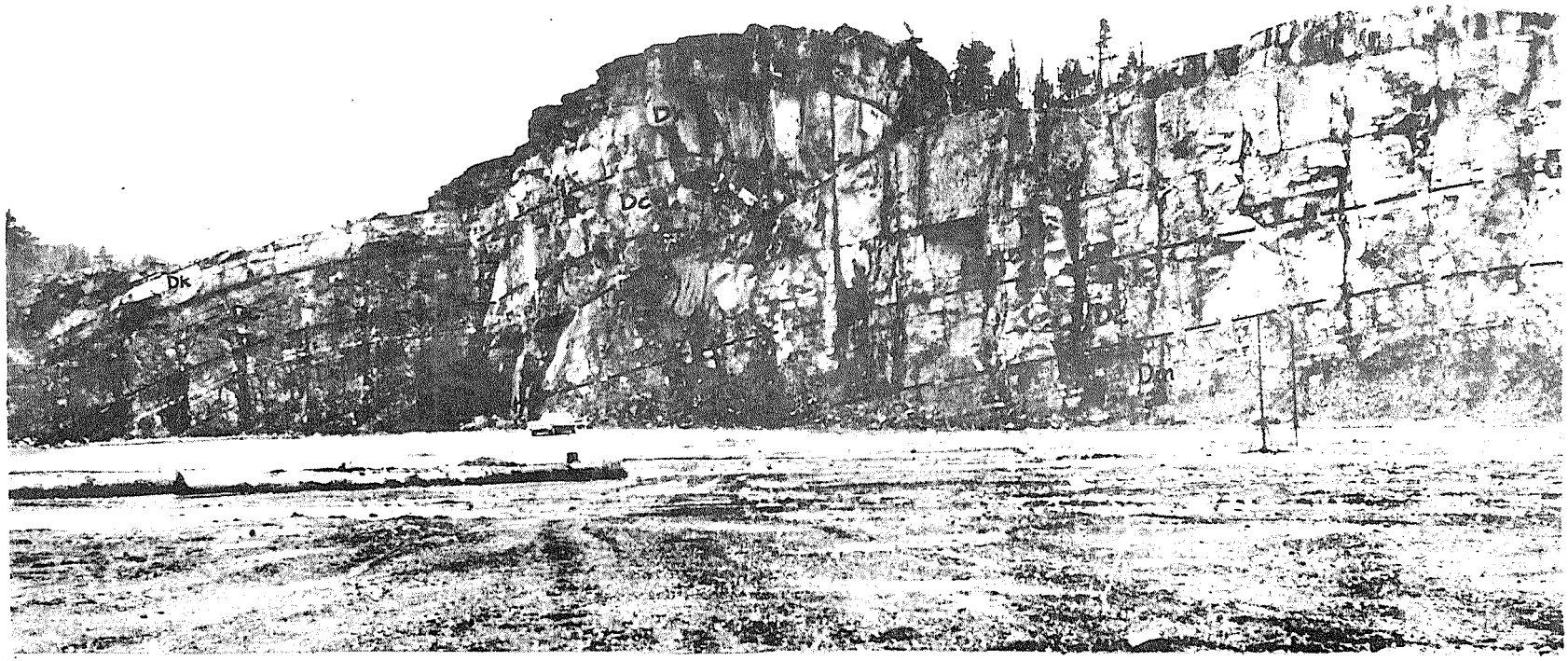


PLATE VIC

Callanan Road Improvement Company, South Bethlehem quarry, looking south. A thrust fault dipping eastward is overlain by an anticline. Exposed formations are the Manlius (Dm), Coeymans (Dc), and Kalkberg (DK) (upper & lower Hannacroix).