THE FOUNDERS OF AMERICAN GEOLOGY: A VISIT TO THEIR TOMBS, LABS, AND THEIR FAVORITE EXPOSURES: THE DEVONIAN LIMESTONES OF THE CAPITAL DISTRICT; A STUDY OF THE SEQUENCE STRATIGRAPHY OF THESE LIMESTONES

GERALD M. FRIEDMAN
Brooklyn College and the Graduate School of CUNY
and Northeastem Science Foundation
affiliated with Brooklyn College-CUNY
15 Third Street,Box 746
Troy, N.Y. 12181-0746

INTRODUCTION

Located along the Helderberg Escarpment this classic site is on hallowed ground. Amos Eaton (1776-1842), Ebenezer Emmons (1799-1863), James Hall (1811-1898), William W Mather (1804-1859), Sir Charles Lyell (1797-1875), Benjamin Silliman (1779-1864), James D. Dana (1813-1895), Louis Agassiz (1807-1873), and Sir William E. Logan (1798-1875) have trod here before you, and we will view the memorial plaque erected in their honor. The field sites expose a large variety of Lower and Middle Devonian limestones, including coral reefs, stromatoporoid reefs, storm deposits, stromatolite facies, skeletal- and lime mud facies, solution-collapse features, and karst. This diversity of facies will be studied in terms of transgressive-regressive cycles, known as **parasequences**, which are defined as *conformable successions of genetically-related beds bounded by surfaces of erosion, called parasequence surfaces*.

HISTORY OF GEOLOGY

Before viewing the sequence stratigraphy of the Devonian we will pay tribute to the founders of American geology on whose concepts modern geology has built. Among those particular attention will be given to Amos Eaton, James Hall, and Ebenezer Emmons, whose debt we have incurred as builders of our science and at whose graves we will pay our respects. This field trip will begin in Troy, N.Y.

Troy, the hallowed ground of the geologic pioneers, is located in Rensselaer County, New York, named after the distinguished Van Rensselaer family who established the only successful Dutch Patroonship which thrived as a manorial estate from 1630 to the mid-1800's. One branch of the family produced Jeremias Van Rensselaer (1793-1871), a then well known, but now largely forgotten, nineteenth century geologist who wrote one of the first geology textbooks published anywhere. Entitled "Lectures on Geology, being Outlines of the Science" and published in 1825, this book preceded the textbooks of the other two "Giants of Geology" from Troy, Ebenezer Emmons (1826) and Amos Eaton (1830)(Fig. 1). More important to the purposes of this field trip, however is Stephen Van Rensselaer, born on November 4, 1764, who was a twelfth generation descendant of the original Dutch immigrant patroon. He graduated from Harvard University in 1782 served as New York State legislator from 1791 to 1796, as Lieutenant Governor of New York from 1795 to 1798, and as General of the New York State militia. His father, likewise Stephen Van Rensselaer, was the eighth and last Patroon and 6th Lord of the Manor of Rensselaerwyck; his mother was Catharine Livingston, daughter of Philip Livingston, one of the signers of the Declaration of Independence (Florence Van Rensselaer, 1956, p. 24,37).

In 1819 the legislature of the state of New York elected Stephen Van Rensselaer President of the Central Board of Agriculture. This board published two volumes on the geology of Albany and Rensselaer Counties authored by Amos Eaton. "It was believed then, and it is believed now, that these were the first two attempts in this country to collect and arrange

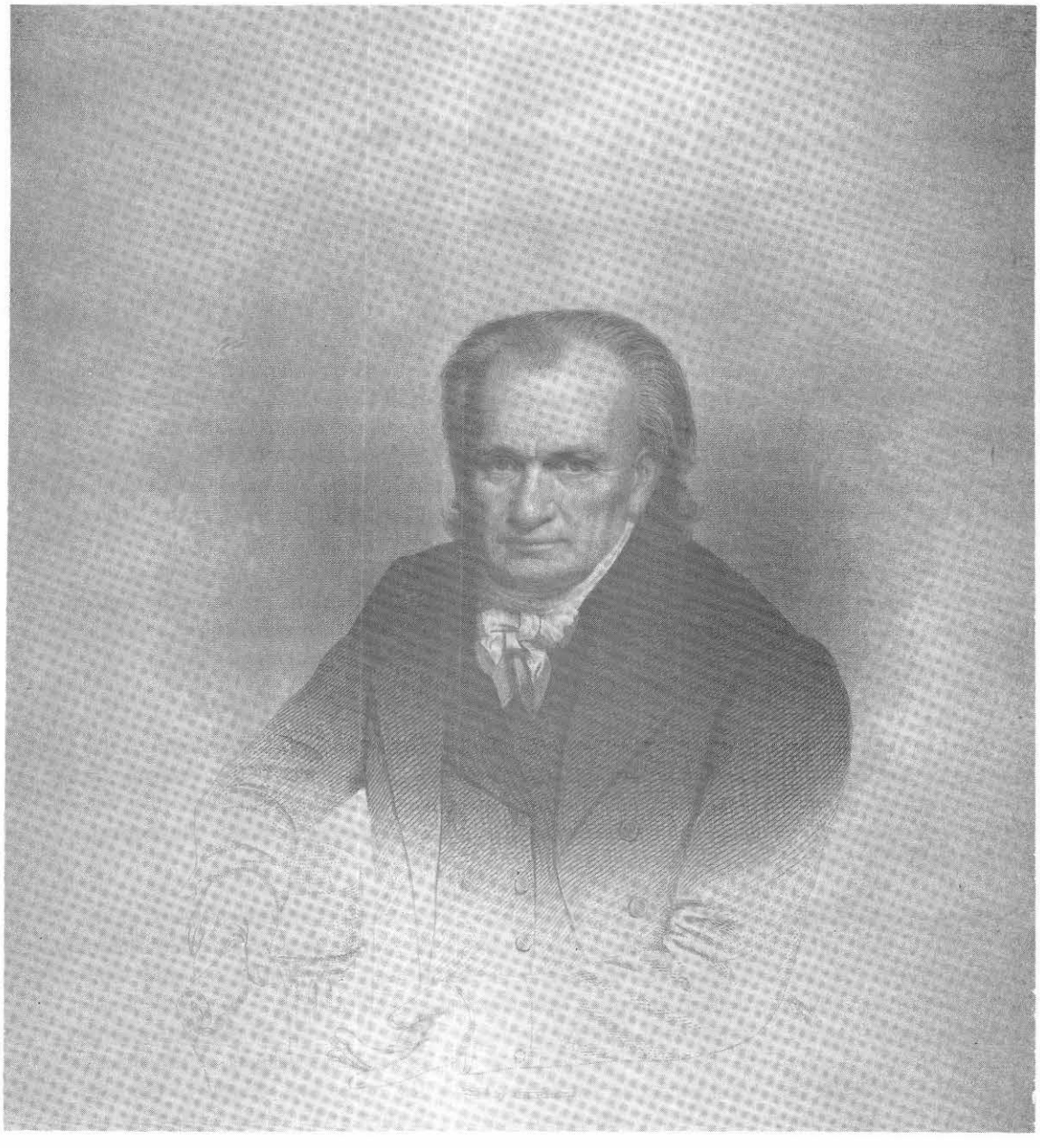

FIGURE 1. Amos Eaton in middle life.

geological facts, with the direct view to the improvement of agriculture" (Barnard 1839, p. 72). In Barnard's (1839) "Life, Services and Character of Stephen Van Rensselaer" he dwelt at length on Van Rensselaer's geological contributions: after republishing the studies on the geology of Albany and Rensselaer Counties "at his own cost, in a separate and convenient form, for extensive and gratuitous distribution" (Barnard,1839, p.74), he next turned his attention to a more extended scientific survey, to be carried through the entire length of the State on the line of the Erie Canal. This was commenced and prosecuted, under his orders, in the fall of 1822 by Professor Amos Eaton aided by two competent assistants. Van Rensselaer considered the geological studies of these two counties and the Erie Canal route part of a grander scheme, a plan for a "large and generous contribution to the science of Geology." This plan embraced a particular examination of the strata and formation of American rocks, by the survey of a transverse section, running across the Great Primitive Ranges of New England and the Transition and Secondary Ranges of eastern and western New York (Barnard,1839, p.75). He engaged Amos Eaton who completed this survey in 1823. His section extended from Boston to Lake Erie, a distance of about 550 miles, stretching across 9° of longitude and embracing a belt about 50 miles wide. At the same time, Professor (Edward) Hitchcock was employed to make a similar survey of a section across New England, a few miles north of that taken by Professor Eaton. In 1824, a publication was made, containing the results of these surveys, with maps exhibiting a profile view of the rocks in each of the sections. This work presents a connected actual inspection and survey, of greater extent than had ever been offered to geology.

However, according to Barnard (p.76) "the crowning glory of this good man's life" resulted on November 5, 1824 in the founding of the Rensselaer School, now Rensselaer Polytechnic Institute, to which he appointed two professors, a senior professor Amos Eaton, pathfinder of North American stratigraphy and one of the founders of American geology, and a junior professor, Lewis C. Beck, later to be the famous State Mineralogist of New York, who was followed by Ebenezer Emmons , one of the giants of nineteenth century American geology. By 1839, Rensselaer " had furnished to the community more State Geologists than has been furnished, in the same time, by all the colleges of the Union" (Barnard, 1839, p. 83), found in Friedman (1979,1981).

Amos Eaton, has been acclaimed the "Father of American Geology." He completed geological surveys of Albany and Rensselaer Counties, commissioned by the New York State Agricultural Society, but paid for by Stephen Van Rensselaer. Van Rensselaer also supported Eaton's geological survey of the territory adjoining the Erie Canal route during 1823-1824. In 1818 Eaton published a textbook, "An Index to the Geology of the Northern States." In this book Eaton not only incorporated a time and rock classification scheme, but also introduced a local guidebook, and published a cross section extending from the Atlantic Ocean to the Catskill Mountains. In 1824 Eaton appealed to Van Rensselaer for $300 as part of the effort to establish the Rensselaer School in Troy. Van Rensselaer provided these funds immediately and continued his financial support until 1829 when he ceased direct support of the school. Despite a heavy load of teaching and administration, Eaton published in 1830 a "Geological Textbook, Prepared for Popular Lectures on North American Geology;" its second edition appeared in 1832. In the second edition Eaton emphasized the importance of field work: students "must be shown the nearest rocks, from day to day." Eaton took his students on long field excursions into the mountains of New England and along the Erie Canal. At the time of his death in 1842, Eaton had become the most influential American geologist. In 1841 Sir Charles Lyell, during his trip to North America visited Eaton at Rensselaer. Eaton likewise received the respects of the Rev. William Buckland (1784-1856), the first professor of mineralogy and geology in the University of Oxford, England. In American geology the period 1818 and 1836 is known as the "Eatonian Era".

Among the most influential alumni of Rensselaer was James Hall, State Geologist of New York, known as the "Father of Geosyncline." In 1857 (published in 1859) Hall observed that, where the Paleozoic marine strata are thin (thicknesses of only few hundred or few thou-

sands of meters), they are flat lying. In contrast,within the Appalachians thicknesses of equivalent age strata amount to tens of thousands of meters and the strata are not horizontal. Hall hypothesized that the subsidence of the strata within a trough, where they would be extra thick, provided the mechanism for folding them (Friedman and Sanders, 1978, p.435). Hall likewise, has become known as "Father of American Stratigraphy" and similarly, "Father of American Paleontology." Probably no other single person exerted a more influential role in the development of paleontology in North America.

James Hall is alleged to have originally literally walked the 220 miles from his home in Hingham, Massachusetts, to Rensselaer so that he might enroll and study under the great Eaton. Hall's first job at Rensselaer included whitewashing one of its buildings and tidying up the school; later he became librarian, and by 1835 he was listed as a full professor. Persuaded by Eaton, the New York State Legislature established a Geological and Natural History Survey in 1836 to which James Hall was appointed.

Another early alumnus who became a giant in the nineteenth century was Ebenezer Emmons. A graduate of Rensselaer in the first class of 1826, Emmons had been inspired by Eaton. Earlier, Emmons had studied under Eaton at Williams College when Eaton taught there in 1817. Emmons became Junior Professor at Rensselaer, a position he held for ten years, and a member of the New York State Geological Survey in 1836.

FIELD PROGRAM

We will first convene at the Rensselaer Center of Applied Geology, a center serving as Headquaters of the Northeastern Science Foundation, and affiliated with Brooklyn College and Graduate School and University Center of the City University of New York. This center was named after Jeremias Van Rensselaer whose 1823 publication An Essay on Salt, Containing Notices of its Origin, Formation and Geological Position and Principal Localites, Embracing, A Particular Description of the American Salines inspired the creation of one of the Foundation's journal Carbonates and Evaporites. Jeremias Van Rensselaer has been called the father of evaporite geology.

At the center we will view originals of the following publications which are central to understanding the development of American geology:

Eaton, Amos, 1822, A Geological and Agricultural Survey of Rensselaer County in the State of New York: Albany, E. and A. Hosford, 70 p.

_____, 1824, A Geological and Agricultural Survey of the District Adjoining the Erie Canal, in the State of New York: Albany, Parkard and Van Benthuysen, 163 p.

_____, 1830, Geological Textbook. Albany, Webster and Skinners, 63 p.

Emmons, Ebenezer, 1842, Geology of New York, Part II; Survey of the Second Geological District: Albany, W. & A White and J. Visscher, 427 p.

_____, 1846, Agriculture of New York: Albany, C. Van Benthuysen & Co., 371 p.

_____, 1854, Agriculture of New York: Albany, C. Van Benthuysen & Co., 267 p. and 47 plates.

Hall, James, The Natural History of New York, "Geology" and "Paleontology", 1843, 1847, 1852, 1859, 1861, 1867, 1879, 1884, 1885, 1893, 1894.

The local field trip begins with a visit to the grave of Amos Eaton at Oakwood Cemetary in Troy where we pay our respects (Fig.2) (STOP 1). Not far from Amos Eaton's grave is that of another distinguished American, Samuel Wilson (1766-1854), better known as Uncle Sam. The United States is nicknamed "Uncle Sam" in much of the world without knowing that "Uncle Sam" was in fact a distinguished citizen. During the War of 1812 Sam Wilson marked military supplies with the initials U.S., which came to stand for both United States and Uncle Sam. Wilson was one of the prime movers for incorporation of Troy as a village (1794) and as a city (1816).

After our visit to Eaton's grave we follow in the footsteps of Sir Charles Lyell. In 1841 (Lyell,1845) he reported on landslides in the city of Troy in which many people were killed. Lyell does not provide his source of information, but it may be the January 4,1837 edition of the *Albany Argus* which under the headline "Dreadful Calamity - Several Lives Lost" reported that in Troy "an avalanche of clay came tumbling from an eminence of 500 feet, moving down the base of the hill to level land, and then continued from the impulse it received to the distance of about 800 feet, covering up acres of ground, accompanied with a cataract of water and sand, which kept up a terrible roar. The mass moved along with great rapidity, carrying with it two stables and three dwelling houses." Lyell does not describe the geological setting for these slides. At the end of the Pleistocene the slope between the Hudson River and the plateau on which South Troy is located formed the shelf and slope of a vanished glacial lake, now known as Lake Albany. Slippery varved lake clays mark its sediments. This kind of setting is an invitation for disaster, and we will view the scarps resulting from slides at South Troy's Prospect Park. Although his location is not precise, Sir Charles Lyell probably inspected these same scarps.

From the Oakwood Cemetary in Troy we will cross the Hudson River to visit the Albany Rural Cemetary to see the graves of James Hall and Ebenezer Emmons (STOP 2).

Our next stop is in Lincoln Park, Albany, where James Hall and his co-workers did their research (STOP 3). A plaque on the building states: "This building was erected by James Hall, State Geologist of New York 1836-1898. For fifty years it served as his office and laboratory and from it graduated many geologists of merit and distinction. During most of that period it was an influential and active center of geological science in this country. Erected by the Association of American State Geologists 1916".

From Lincoln Park, Albany, we move on to the Indian Ladder Trail at the John Boyd Thacher State Park near Albany (Fig. 3).

Located in the Altamont and Voorheesville quadrangles, this classic site is on hallowed ground. A plaque erected in 1933 in memoriam of those pioneer geologists whose researches in the Helderbergs in the nineteenth century made this region classic ground includes not only almost all American pioneer geologists, but in addition lists pioneers of British and Canadian geology. Among those listed are Amos Eaton (1776-1842), the John Gebhards Sr. and Jr., James Hall (1811-1898), William W. Mather (1804-1859), Lardner Vanuxem (1792-1848), James Eights (1797-1882), Sir Charles Lyell (1797-1875), Benjamin Silliman (1779-1864), Edouard de Verneuil (1805-1873), James D. Dana (1813-1895), Henry D. Rogers (1808-1866), William B. Rogers (1804-1882), Ferdinand Roemer (1818-1891), Louis Agassiz (1807-1873), and Sir William E. Logan (1798-1875).

Sir Charles Lyell visited the "Helderberg Mountains", as he called them, in September 1841 and although he rejoiced, noting that "the precipitous cliffs of limestone, render this region more picturesque than is usual where the strata are undisturbed" (1845, p. 67), he was more concerned in his account with the "Helderberg war" between Van Rensselaer and his tenants. On his return to the "Helderberg Mountains" in May 1846 the "Helderberg war" absorbed him again since he states that "the anti-renters have not only set the whole militia of the site at defiance, but have actually killed a sheriff's officer, who was distraining for rents" (Lyell,

FIGURE 2. Gravestone of Amos Eaton in Oakwood Cemetary, Troy, N.Y.

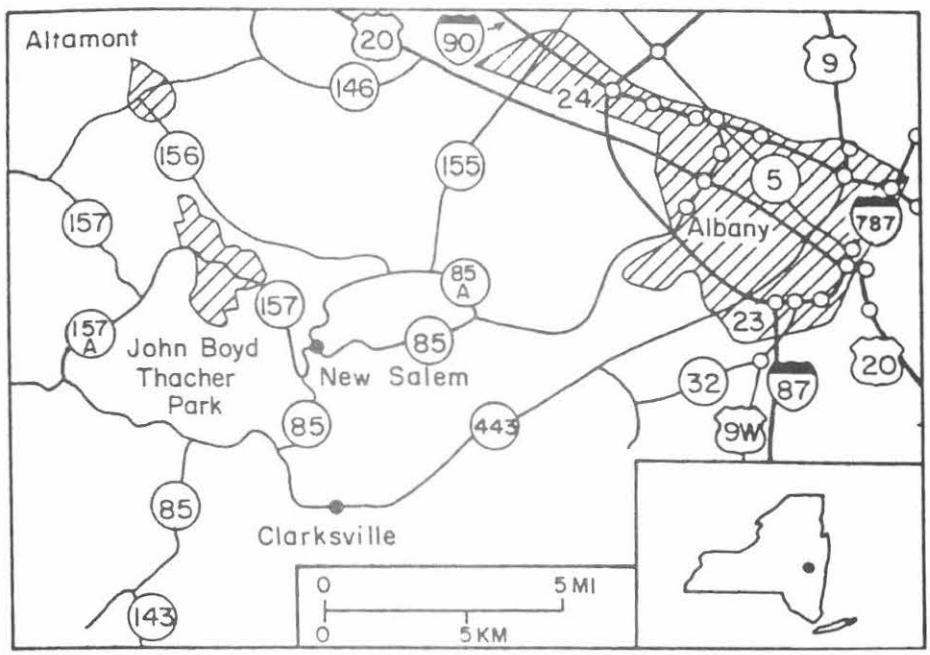

FIGURE 3. Location of John Boyd Thacher State Park (Fisher, 1987). The Indian Ladder Trail is located on Route 157.

1849, p. 260).

The definitive studies of the Lower Devonian carbonates of the Helderberg Escarpment exposed at John Boyd Thacher Park date to the early New York State Geological Survey and were written by Vanuxem (1842), Mather (1843), and Hall (1843). Their reports were supplemented and complemented later in the nineteenth century by the many volumes and papers by James Hall detailing stratigraphy and paleontology, followed in this century by many others, including Fisher (1987), Goldring (1935, 1943), Goodwin and Anderson (1982, 1985), Laporte (1967, 1969), Rickard (1962, 1975). and Friedman (1990). Gurney and Friedman (1986) described vertical parasequences of Lower Devonian limestones as transgressive-regressive cycles in Cherry Valley, approximately 35 miles west of Thacher Park.

The Indian Ladder Trail site provides an unusual opportunity to study a vertical cliff of limestone strata: a vertical exposure of approximately 80 ft or 24 m exposed in the cliff is accessible by stairway and footpath; handrailings assure safety. One can view the entire sequence of the rocks at close quarter, including by hand lens; comparable physical settings in quarries never allow such inspection.

LOCATION AND LOCAL HISTORY

Figure 3 shows the location of the John Boyd Thacher State Park where the Indian Ladder Trail reveals the vertical sequence of Lower Devonian limestones. Why the name Indian Ladder? Verplanck Colvin, one of the earliest men to write about the Helderbergs, in 1869 wrote:

"What is this Indian ladder so often mentioned? In 1710 this Helderberg region was a wilderness; nay all westward of the Hudson River settlement was unknown. Albany was a frontier town, a trading post, a place where annuities were paid, and blankets exchanged with Indians for beaver pelts. From Albany over the sand plains... "Schenectada", (pine barrens) of the Indians... led an Indian trail westward. Straight as the wild bee or the crow the wild Indian made his course from the white man's settlement to his own home in the beauteous Schoharie valley. The stern cliffs of these hills opposed his progress; his hatchet fells a tree against them, the stumps of the branches which he trimmed away formed the round of the Indian ladder."

The trail ended where the cliff did not exceed twenty feet in height. Here stood "the old ladder." In 1820 this ladder" was yet in daily use (Goldring, 1935). The modern stairway crosses the old Indian ladder road which ran to the top of the escarpment where the trail begins.

Entering Thacher State Park from Albany on Route 157 stop at the "Cliff Edge Overlook" for a view of the Taconic and Berkshire Mountains, Adirondacks, Hudson River, and City of Albany, then drive to the next parking lot which has a sign La Grange Bush Picnic Area - Indian Ladder Trail. Descend here for study of the Lower Devonian carbonate facies. Examine also the memorial plaque near the cliff edge at the Mine Lot Creek parking lot which has been attached to a vertical rockwall. It says "in memory of those pioneer geologists whose researches in the Helderbergs from 1819 to 1850 made this region classic ground". The names of these pioneers have been cited in the introduction to this paper.

SIGNIFICANCE

The cliff face exposes an excellent case history of sequence stratigraphy. Lower Devonian limestones of the Helderberg Group reveal three parasequences which may be recognized among the exposed formations (Rondout, Manlius, and Coeymans formations) (Figs.4&5). Parasequences are the building blocks of vertical sequences. A parasequence is defined as a relatively conformable succession of genetically related beds bounded by surfaces (called parasequence surfaces) of erosion, nondeposition, or their correlative conformities (Van Wagoner. 1985). Each

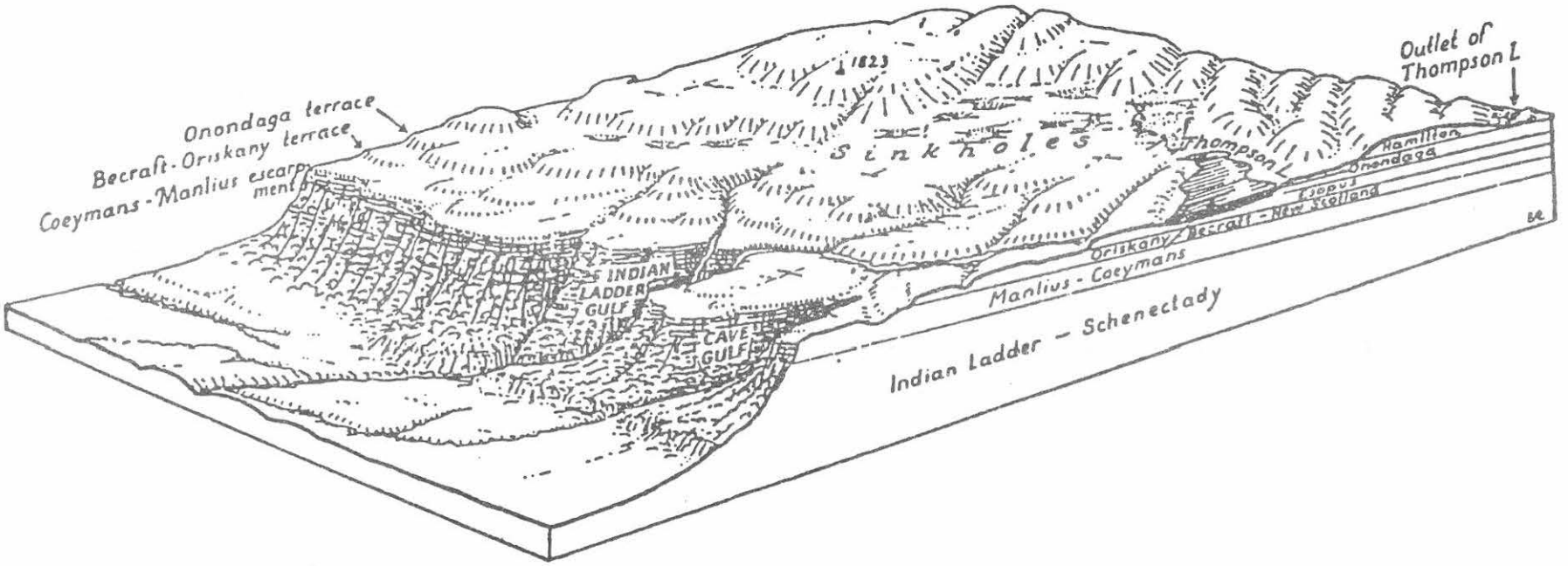

FIGURE 4. Block diagram of Helderberg Escarpment showing Indian Ladder location (labeled Indian Ladder Gulf), dip-slope of Paleozoic strata, prominent terraces, and sinkhole topography (H. F. Cleland, 1930; modified by Winifred Goldring, 1935).

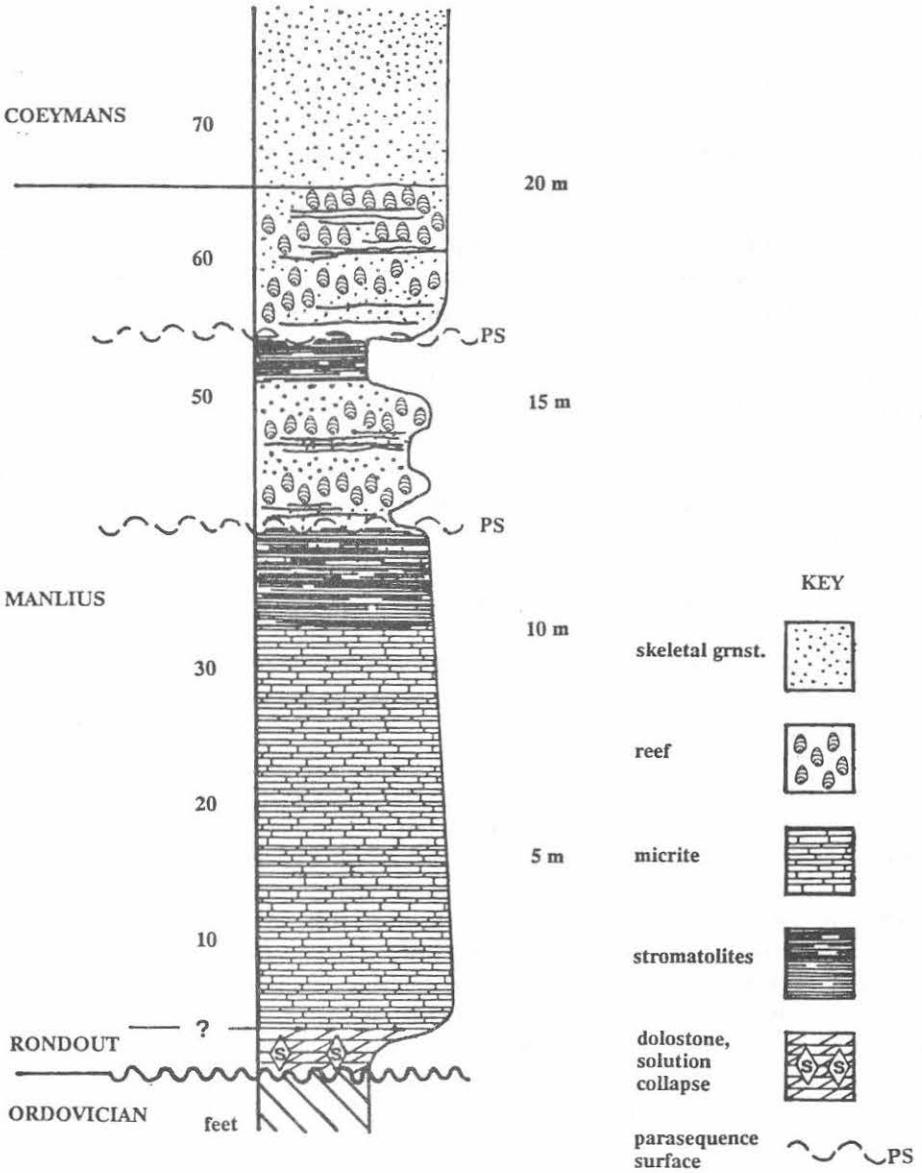

FIGURE 5. Stratigraphic section and vertical sequence revealing parasequences at Indian Ladder Trail.

sequence is initiated by a eustatic fall in sea level rapid enough to overcome subsidence or by epeirogenic upward motion. A parasequence surface commonly is an unconformity surface.

THE STRATIGRAPHIC COLUMN

Below the Indian Ladder Trail, where a waterfall known as Minelot Falls spouts across the path, sandstones and shales of the Middle Ordovician Schenectady formation are mostly concealed beneath a cover of blocks of Devonian limestone forming a talus slope. At the waterfall a major unconformity just below the trail separates the Ordovician strata from the Rondout Formation exposed at the base of the cliff. The nonfossiliferous Rondout Formation has been classed as latest Silurian or earliest Devonian (Fisher, 1987).

Figure 4 shows the columnar stratigraphic section, the parasequence surfaces, and facies distribution of the Lower Devonian carbonates. The Rondout Formation at the base is overlain by the Manlius Formation, and the top of the section extending to the break in slope at the top of the cliff is occupied by the Coeymans Formation. The stratigraphic section exposed on this trail is the type locality for the Thacher Member of the Manlius Formation, proposed by Rickard (1962).

PARASEQUENCES

Studies of vertical sequences should normally be worked from the base of the section upward. However, at this exposure it is best to work the section downward following the stairway from the edge of the cliff.

The top of the section is composed of skeletal grainstone (locally skeletal packstone) in which fossils, especially brachiopods, corals and crinoids, are evident (Fig. 5); the pentamerid *Gypidula coeymanensis* is prevalent. This facies is part of the Coeymans Formation. Its lower contact is sharp and obvious in the field. Below this contact follows the Manlius Formation which underlies most of this escarpment. A stromatoporoid reef with loclly intercalated skeletal grainstone represents the top of this formation (Fig. 5). The stromatoporoids show their distinctive globular concentric structures resembling cabbage heads. Previous authors (Fisher, 1987; Rickard. 1962) have termed this reef facies a biostrome, presumably because its geometry in outcrop is sheetlike rather than moundshaped. In my experience with reefs of all ages I have observed that most large reefs are flat on top and bottom, especially on the scale of this exposure. Other geologists share this experience, thus Shaver and Sunderman (1989) note "virtually all large reefs seen on outcrop have eroded, flattened tops, whereas smaller reefs that were not naturally aborted and that were unaffected by erosion as seen on outcrop have convex-upward rounded tops".

Close examination of the reef facies reveals a fine-grained matrix between the framework-building stromatoporoids. This matrix resembles micrite, a lithified former lime mud; hence this facies may be misinterpreted as representing a low-energy setting.
However, in analogous modern reefs cement forms millimeters to centimeters beneath the living part which in thin section is finely crystalline (cryptocrystalline) and semi-opaque. Hence the matrix in such reef rock looks just like low-energy micrite (Friedman et al., 1974). Case histories abound where unwary geologists have confused high-energy reef rock with a supposed "low-energy" lime-mud facies (Friedman, 1975). Therefore the observation of a fine-grained matrix between the framework builders does not deter, in fact confirms, the interpretation that this part of the section formed as a high-energy reef facies, and not in a low-energy setting.

The stromatoporoids are massive which in the ecologic zonation of Devonian reefs represents the shallowest-water zone of a subtidal setting.

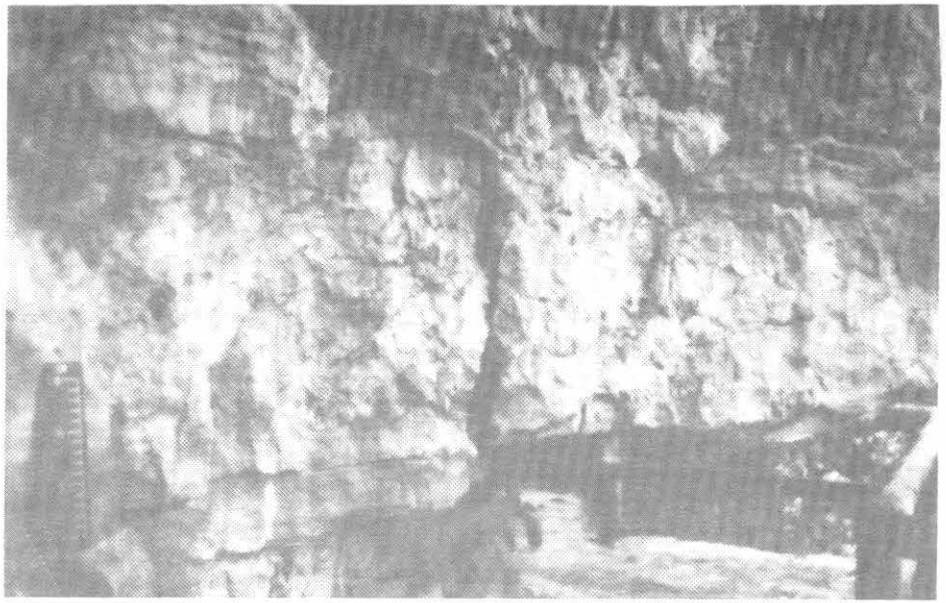

FIGURE 6. Photograph showing recessed underlying stromatolitic (finely-laminated) facies and overlying stromatoporoid reef facies. Sharp contact between the two facies on which scale rests is a parasequence surface (see fig. 5). Manlius Formation.

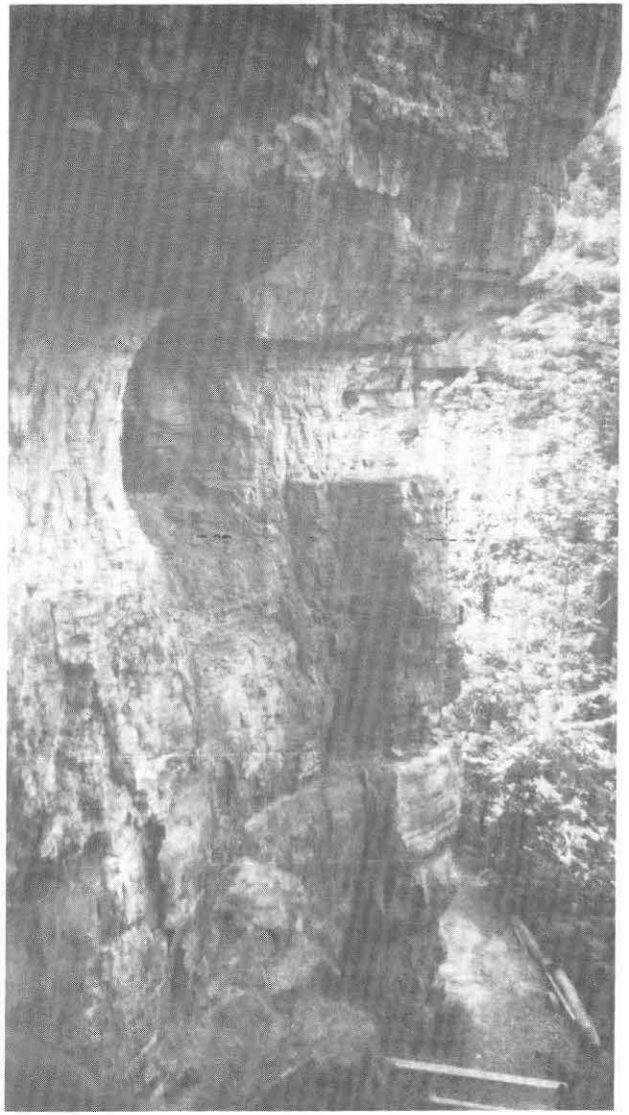

FIGURE 7. Photograph showing from top downward: massive projecting reef separated by parasequence sur face from underlying recessed stromatolites ("Upper Bear Path"). Below recessed stromatolite facies note in descending order bedded skeletal grainstone, nonbedded reef, bedded skeletal grainstone, reef, parasequence surface, and non-recessed stromatolite facies recognizable as a well-bedded facies. For detail compare with figure 5. Manlius Formation.

Below the reef facies occurs a stromatolitic (finely laminated) facies which is recessed back creating a near cavelike morphologic feature (Fig. 6). This recessed feature can be traced throughout Thacher State Park and is known as "Upper Bear Path". By analogy with modern environments the stromatolitic facies represents a low-energy intertidal or supratidal setting. The sharp contact between the intertidal or supratidal low-energy stromatolitic facies and overlying subtidal high-energy reef facies represents a parasequence surface (Figs. 5 and 6). Downward from the stromatolites a stromatoporoid reef facies once again recurs, separated by bedded skeletal grainstone from the stromatolites; in fact the reef facies is present twice (Fig. 7). Hence downward the setting changes from intertidal or supratidal to subtidal shallow water. Below this double reef section the change is again to interpreted intertidal or supratitidal stromatolites. Hence once again a parasequence surface separates the subtidal high-energy reef facies from the underlying intertidal to supratidal stramatolites (Fig. 5). Interestingly, this stromatolitic facies is resistant to erosion (Fig. 7), hence projects out in the cliff, whereas the upper stromatolite facies is recessed almost cavelike. Below this lower stromatolite facies the lithology and facies are that of a low-energy thin-bedded micrite with local skeletal grainstone occurring as finely interbedded couplets, scour-and-fill structures, local cross-bedding, and some beds containing abundant spiriferid brachiopods, tentaculitids, ostracodes, and bryozoans. Near the base of the Manlius Formation occur several thicker beds, up to about 20 cm in thickness.

Near the base of the section is the Rondout Formation. Its exact contact with the overlying Manlius Formation is subject to debate. In the columnar section (Fig. 5) the Rondout Formation is identified where solution-collapse features are prominent and the lithology changes to dolomitic, especially dolomitic stromatolites, with sporadic intercalated calcitic laminae and shale laminae, an interpreted supratidal facies. Clasts of solution-collapse breccia are prominent together with gypsum-filled veins. The angular clasts of collapse breccia resulted from collapse and brecciation of overlying carbonate strata when evaporites underlying them were dissolved. It represents a karst setting. The Rondout Formation is commonly known as Rondout Waterlime. Its base is at or below the trail.

ITINARY

From Oneonta drive to Troy, where this itinary begins.

An informal stop will be made at the Rensselaer Center of Applied Geology, 15 Third Street, for informal discussion and scanning of the historical geological publications of Eaton, Hall and Emmons (for titles see HISTORY OF GEOLOGY).

Road Log

CUMULATIVE MILEAGE	MILES FROM LAST POINT	ROUTE DESCRIPTION
0	2.1	From Rensselaer Center of Applied Geology (Third Street, Troy) go via Broadway, River Street, Fulton Street and Sixth Ave. (turn left) to Hoosick St. (Rte 7), turn right; one block on Hoosick St., turn left onto Tenth St. which becomes Oakwood Ave. Enter Oakwood Cemetery. On entering the cemetery keep right 0.1 mile to section S2.
		STOP 1.Visit the grave of the father of American geology Amos Eaton (1776-1842). For details on his life read the section on History of Geology.
		Return to Hoosick Street(Rte. 7) and cross Hudson River to I 787 via Collar Bridge. Drive I 787 south to I 90 and take Watervliet

exit (NY 378) west.

0 2.9 Take NY 378 to first traffic light; turn right into historic Albany Rural Cemetery)(established 1841).

STOP 2. Visit the graves of James Hall (1811-1898) (Lot 93, Section 18) and Ebenezer Emmons (1799-1863)(Lot 46, Section 6).

James Hall. - James Hall was the single most prominent American geologist of the 19th century. The impressive honors he received are worth listing chronologically. Hall obtained the degrees of A.B. and A.M. from Rensselaer in 1831 and 1832. In 1837 he was elected Member of the Imperial Mineralogical Society of St. Petersburg, Russia. In 1840 he was one of the founders of the American Association of Geologists which became the American Association for the Advancement of Science. In 1843 he was elected correspondent of the Academy of Natural Sciences of Philadelphia. In 1848 he was elected Foreign Member of the Geological Society of London, the number of foreign members being limited to 50. In 1848 he was elected fellow of the American Academy of Arts and Sciences. In 1856 he became President of the American Association for the Advancement of Science and in 1863 he was named, by an Act of Congress, to be one of the 50 original members of the National Academy of Science. The King of Italy conferred on him the title of Commander of the Order dei Santi Maurizzio é Lazzaro. Many other honors too numerous to be cited may be added.

Ebenezer Emmons.--alumnus and Junior Professor at Rensselaer, member of the New York State Geological Survey, founder of the North Carolina Geological Survey, and State Geologist of North Carolina; father of the Taconic System.

A graduate of Rensselaer in the first class of 1826, Emmons had been inspired by Eaton. Emmons became Junior Professor at Rensselaer, a position he held for ten years, and a member of the New York State Geological Survey in 1836. Later he was State Geologist of North Carolina, spreading Rensselaer's influence in American geology through his textbooks and advocacy of the Taconic system. Emmons had noted the presence of a group of rocks between the Potsdam Sandstone, the lowest of the sedimentary formations in New York and what was at the time called the Primitive Rocks of Central Vermont. This interval he proposed to call the Taconic System. Emmons acquainted the public with the Adirondack Region and gave the names to principal mountains. Classics which Emmons published include Manual of Mineralogy and Geology (1826), Report on the Second Geological District of New York (1842), Natural History of New York (1848), American Geology Containing a Statement of Principles of the Science With Full Illustrations of the Characteristic American Fossils (1854), Treatise Upon American Geology (1854), The Swamplands of North Carolina (1860), and Textbook of Geology (1860).

The antagonism of Hall helped chase Emmons out of New York. Yet in death their graves, close to each other, make their old controversy seem remote. Hall never acknowledged Emmons' thought-provoking studies on the Adirondack and Taconic Regions. One of the Adirondack peaks has been named Mount Emmons.

0 1.3 Leave Albany Rural Cemetery. At Exit (traffic light) turn left , enter the village of Menands, drive to junction with 787, go south to Albany.

5.7 4.4 Take exit US 20 at Port of Albany, go straight on Madison Avenue (Rts. 20 and

5.9 0.2 32) to South Pearl St. (make left turn on to South Pearl St.)

6.25 0.35 Go 3 blocks to Morton Avenue and make a right turn on to Morton Ave.

6.8 0.45 Drive 6 blocks to South Swan Street (count blocks on right).

6.9	0.1	Make right turn into South Swan St. and take first left into Lincoln Park. Alight at Sunshine School.

STOP 3. The annex to Sunshine School is the historical laboratory of James Hall. For fifty years this building served as his office and laboratory.

Return to I 787 North

0	1.8	To I 90 West
4.1	5.9	Take I 90 to Slingerlands (Exit4) Route 85. At traffic light turn right (west) into NY 85.
6.8	12.7	Enter Town of New Scotland
5.4	18.1	Take 157 west
2.2	20.3	Enter John Boyd Thacher Park
1.2	21.5	Park in La Grange Bush Picnic Area. Indian Ladder Trail.

STOP 4. Indian Ladder Trail at the John Boyd Thacher State Park.
Before descending to see the exposures read the sections titled *Significance, the Stratigraphic Column, and Parasequences.* Study especially figure 5. Then descend.

Study the section as you descend to the base of the trail: identify the facies, parasequence surfaces, contacts, and formations. On your return to the top of the section measure the thickness of various stratigraphic and facies units and plot them on a striplog or in a notebook. Compare your data with those shown on figure 5. After completion of the exercise visit the memorial plaque at the top of the trail near Mine Lot Creek parking lot. It is this plaque which explains why the ground on which you tread at this site is sacred.

REFERENCES

Barnard, D.D., 1839, A discourse on the life, services and character of Stephen Van Rensselaer. delivered before the Albany Institute April 15, 1839: Albany, Hoffman and White, 144 p.

Cleland, H.F., 1930, Post-Tertiary erosion and weathering: American Jour. Sci., v. 19, p. 289-296.

Colvin, Verplanck, 1869, The Helderbergs. Harper's New Month Magazine, v. 39, p. 652-657.

Eaton, Amos, 1830, Geological textbook prepared for popular lectures on North American geology. Albany, Webster and Skinner, printers, 63 p.

Emmons, Ebenezer, 1826, Manual of mineralogy and geology. Albany, Websters & Skinners, printers, 230 p.

Fisher, D.W., 1987, Lower Devonian limestones, Helderberg Escarpment, New York: Geol. Soc. America Centennial Field Guide, Northeastern Section, p. 119-122.

Friedman, G.M., 1979, Geology at Rensselaer: a historical perspective, p. 1-19 *in* Friedman, G.M., *ed.*, Guidebook for Field Trips, New York State Geol. Assoc. 5lst Annual Heeting, and New England Intercollegiate Geol. Conference 7lst Annual Meeting, 457 p.

_____, 1981, Geology at Rensselaer Polytechnic Institute: an American epitome: Northeastern Geology, v. 3. p. 18-28.

_____, 1983, "Gems" From Rensselaer, Earth Sciences History, v.2, no.2, p.99-102.

_____, 1985, The problem of submarine cement in classifying reef rock: an experience in frustration, p. 117-121, *in* Schneidermann, N. and Harris, P. M., *eds.*, Carbonate Cements, Soc. Economic

Paleontologists and Mineralogists, Special Publ. No. 36, 379 p.

Friedman, G. M., Amiel, A. J. and Schneidermann, N., 1974, Submarine cementation in reefs: example from the Red Sea: Jour. Sedimentary Petrology, v. 44, p. 816-825.

Friedman, G. M. and Sanders, J. E., 1978, Principles of sedimentology. New York, Wiley, 792 p.

Goldring, W. 1935, Geology of the Berne Quadrangle: New York State Museum Bulletin 303, 238 p., map scale 1:62,500.

_____, 1943, Geology of the Coxsackie Quadrangle: New York State Museum Bulletin 332, 374 p., map scale 1:62,500.

Goodwin, P. W. and Anderson, E. J., 1982, Punctuated aggradational cycles and carbonate facies, Helderberg Group (Lower Devonian), New York State, p. A-1 to A-12 1,7 *in* Friedman, G. M., Sanders, J. E., and Martini, I. P., Sedimentary facies: products of sedimentary environments in a cross section of the classic Appalachian Mountains and adjoining Appalachian basin in New York and Ontario: Eleventh International Congress on Sedimentology, Field Excursion Guidebook, McMaster University, Hamilton, Ontario, Canada.

_____, 1985, Punctuated aggradational cycles: a general hypothesis of episodic stratigraphic accumulation: Jour. of Geology, v. 93. p. 515-533.

Gurney, G. G. and Friedman. G. M., 1986, Transgressive-regressive cycles in vertical sequences: an example from Devonian carbonates in Cherry Valley, New York: Northeastern Geology, v. 8, p. 201-217.

Hall, James, 1843, Geology of New York. Part IV, Comprising the Survey of the Fourth Geological District, Carroll and Cook, Albany, New York, 683 p.

Laporte, L. F., 1967, Carbonate deposition near mean sea-level and resultant facies mosaic: Manlius Formation (Lower Devonian) of New York State: Am. Assoc. Petroleum Geologists Bull. v. 51, p. 73-101.

_____, 1969, Recognition of a transgressive carbonate sequence within an epeiric sea: Helder- Group (Lower Devonian) of New York State, *in* Friedman, G. M., *editor*, Depositional environments in carbonate rocks, Soc. Economic Paleontologists and Mineralogists, Spec. Publ. No. 14, p. 98-119.

Lyell, Charles, 1845, Travels in North America in the Years 1841-1842; with Geological Observations in the United States, Canada, and Nova Scotia. Wiley and Putnam, New York: v. 1, 251 p., v. II, 221 p.

_____, 1849, Second visit to the United States of North America. Harper and Brothers, New York, John Murray, London, v. I, 273 p., v. 2, 287 p.

Mather, W. W., 1843, Geology of New York. Part 1, Comprising the Geology of the First Geological District, Carroll and Cook, Albany, New York, 653 p.

Rickard, L. V., 1962, Late Cayugan (Upper Silurian) and Helderbergian (Lower Devonian) stratigraphy of New York: York State Museum Bull. 386, 157 p.

_____, 1975, Correlation of the Silurian and Devonian rocks of New York State: New York State Museum Map and Chart Series 24, 16 p.

Shaver, R. H. and Sunderman, J. A., 1989, Silurian seascapes: water depth, clinothems, reef geometry, and other motifs - A critical review of the Silurian reef model: Geol. Soc. America, v. 101, p. 939-951.

Van Wagoner, J.C., 1985, Reservoir facies distribution as controlled by sea-level change: Soc. Economic Paleontologists and Mineralogists, Abstracts, Annual Midyear Meeting, v. 11, p. 91.

Vanuxem, Lardner, 1842, Geology of New York. Part III, Comprising the Survey of the Third Geological District, White and Visscher, Albany, New York, 306 p.

Van Rensselaer, Florence, 1956, The Van Rensselaers in Holland and America. New York, American Historical Co., Inc. 103 p.

Van Rensselaer, Jeremias, 1823, An essay on salt, containing notices of its origin, formation, geological position and principal localities. New York, O. Wilder and J.H. Campbell, 80 p.

_____,1825, Lectures on geology being outlines of the science delivered in the New York Athenaeum in the year 1825. New York, publ. by E. Bliss & E. White, 358 p.