TRIP I

STRATIGRAPHY OF THE GENESEE GORGE AT ROCHESTER

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INTRODUCTION

The Genesee River, in its northward flow to Lake Ontario, plunges over the Niagara or Lockport Escarpment at Rochester. Diverted from its preglacial outlet through Irondequoit Bay, the Genesee River, since the last ice retreat (8,000 years ago) has carved a post glacial gorge exhibiting a nearly complete exposure of Upper Ordovician to Middle Silurian rocks. Formations of the same age are superbly exposed in the Niagara Gorge and a comparison of the two sections reveals a Lower and Middle Silurian section ideally suited for the illustration of complex facies changes and/or disconformities.

ORDOVICIAN SYSTEM

Upper Ordovician

Queenston Formation - The lowest exposure in the gorge is about 55 feet of unfossiliferous, thin bedded, red shale and siltstone with some red sandstone layers near the top. This consortium of red shale, siltstone, and sandstone is the Queenston Formation. White bloches in the shale and thin green shale layers following the bedding or joint planes, occur throughout the unit. These discolorations are thought to represent the percolation of ground water altering the red ferric oxide stain on the detrital fragments to the ferrous state.

Although only the upper 55 feet are exposed here, the Queenston totals nearly 1000 feet thick and underlies much of the Lake Ontario basin.

Named by Grabau (1908), the Queenston, to the southeast, becomes more sandy and silty, and in Pennsylvania is referred to as the Juniata Formation.

The Queenston and Juniata represent detrital deposits of a huge deltaic complex that spread westward across the Allegheny Basin as a consequence of the Taconic Orogeny (Middle Ordovician to Early Silurian)

SILURIAN SYSTEM

The Silurian System of New York begins with a deltaic sequence (Medina Group), succeeded by a complex marine transgression (Clinton and Lockport Groups), and ends with a sequence of hypersaline deposits and eurypterid-bearing lagoonal carbonates (Salina Group). The Salina Group as presently defined includes, in its upper part, the Bertie Group of older reports.

This framework has resulted in a threefold subdivision of the Silurian into the following series: Medinan (lower), Niagaran (middle), Cayugan (upper). Only the Niagaran was thought to be fossiliferous enough to permit correlation outside of New York State. Since the paleontalogical recognition of the other series away from New York was difficult, Berry and Boucot (1970) suggested that the New York terminology be restricted to this state and adjacent areas, and that future attempts using the New York section for correlation be abandoned. Furthermore, they state that the North American graptolite and shelly faunal succession is similar to that of the British Isles, Scandinavia and Czechoslovakia; enough so to make the European series, (Llandovery, Wenlock, Ludlow and Pridoli) recognizable in North America and subdivided into Lower and Upper Silurian. Therefore these series names should replace Medinan, Niagaran and Cayugan.

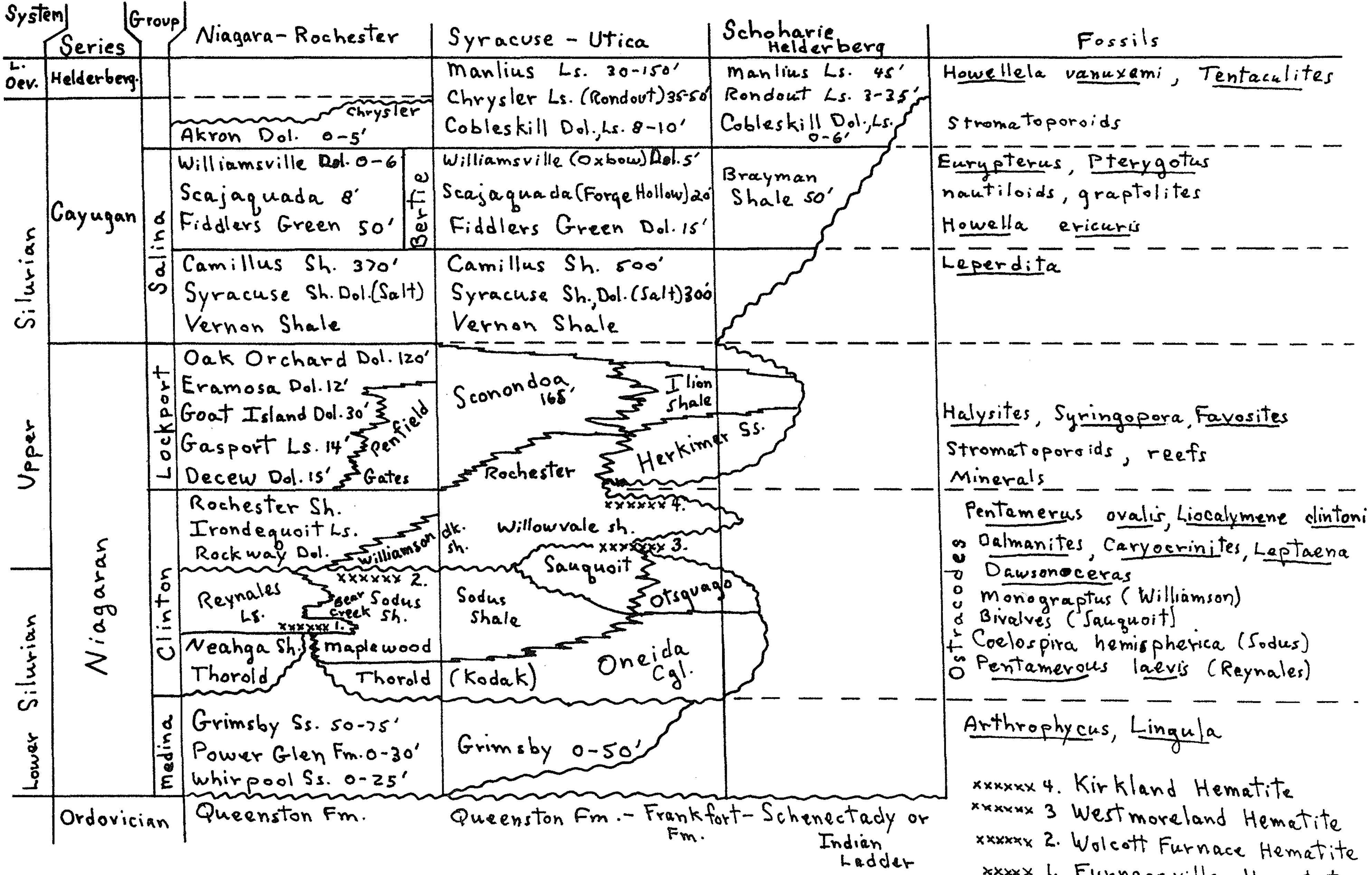
Many refinements in the correlation and subdivision of the New York Silurian have been accomplished in recent years. The major obstacles that impeded the study of the New York Silurian were the numerous disconformities, the lack of fossils in many units, and the change of facies eastward, toward the source area, into coarse clastics or red beds. These have been largely overcome by careful tracing of physical units using numerous closely spaced sections, more precise paleontological sampling and the widespread use of ostracodes and conodonts for correlation. This has yielded greater time stratigraphic control, thereby making Niagaran and Cayugan correlations more reliable outside the standard section. This usage has been adopted here.

Table 1 shows the relationships of the New York and European Series along with the graptolite, ostracode and conodont zones. Table 2 is a generalized chart of the Silurian section of New York (unpublished Silurian Correlation Chart - courtesy L. V. Rickard; Berry & Boucot 1970).

Table 1

Old American Standard			Present European Standard				Present American Standard				
Syst.	Series	Rock Unit	System	Series	Graptolite zones	Conodont Zones	System	Series	Rock Unit	Ostracode Zones	Conodont Zones
Lower Devonian			Upper Silurian	Downtonian (Pridolian)	Monograptus transgrediens	Spathognathodus steinhornensis eosteinhornensis	Upper Silurian	Cayugan	Rondout Fm. Salina Group	? Drepanellina clarki	S. sp. cf S. canadensis
					Monograptus ultimus						Spathognathodus snajdri
Upper Silurian	Cayugan	Akron–Rondout		Ludlovian	Monograptus thuringicus	Spathognathodus crispus		Niagaran	Lockport Group		Polygnathoides siluricus
		Bertie Group			Saetograptus leintwardinensis	Polygnathoides siluricus					
		Salina Group			Pristiograptus tumescens						
					Cyrtograptus scanicus						
Middle Silurian	Niagaran	Lockport Group			Neodiversograptus nissoni	A. ploeckensis O. crassa					
				Wenlockian	Pristiograptus ludensis	Spathognathodus sagitta sagitta				Paraechmina spinosa	Spathognathodus sagitta sagitta
					Cyrtograptus lundgreni						
		Clinton Group			Cyrtograptus ellesae				Clinton Group		
					Cyrtograptus linnarsoni	Kockella patula					Kockella patula
					Cyrtograptus rigidus						
					Monograptus riccartonensis						
					Cyrtograptus murchisoni						
					Cytrograptus centrifugus	Pterospathodus amorphognathoides				mastigobolbina typa	Pterospathodus amorphognathoides
			Lower Silurian	Llandoverian	Monoclimacis crenulata		Lower Silurian				Spathognathodus celloni
					Monoclimacis griestoniensis	Spathognathodus celloni				mastigobolbina lata	
					Monograptus crispus						
					Monograptus turriculatus						
					Monograptus sedgwickii					Z. decora	
					Monograptus convolutus	?				Zygobolba excavata	Icriodina irregularis
					Monograptus gregarius						
					Monograptus cyphus						
Lower Silurian	Medinan	Medina Group			Orthograptus vesiculosus				Medina Grp.	?	Panderodus simplex
					Akidograptus accuminatus						
					Glyptograptus persculptus						

Table II
Generalized Silurian Section
West - Central - East New York



xxxxxx 4. Kirkland Hematite
xxxxxx 3 Westmoreland Hematite
xxxxxx 2. Wolcott Furnace Hematite
xxxxx 1. Furnaceville Hematite

LOWER SILURIAN - MEDINA GROUP

Grimsby Formation - Extensively quarried for building stone and curbing, the Grimsby Formation or Red Medina Sandstone of older reports, is one of the more prominent units of the Lake Ontario Plain. Named by Williams (1919) it forms a minor escarpment west of Rochester and north of the well pronounced Lockport or Niagaran Cuesta.

In the Niagara Gorge the Queenston and Grimsby Formations are separated by nearly 60 feet of strata; 22 feet of white crossbedded Whirlpool Sandstone (Grabau 1909) or White Medina of earlier workers, followed by 48 feet of Power Glen Formation (Bolton 1953, 1957) of interbedded gray shales and siltstones. Traced eastward these two units pass laterally into the lower Grimsby.

Fisher (1966) has recognized three facies within the Grimsby in Orleans and Niagaran Counties west of Rochester. Facies "a", the lowest one, is a marine intertidal facies of pink and mottled siltstone containing abundant Lingula cuneata. It passes eastward into facies "b" east of Medina. The middle "b" facies is a thick bedded red sandstone with large scale crossbedding and the worm burrow Arthrophycus allegheniensis. It is this facies that has supplied most of the building stone and is probably supratidal in origin. The upper facies "c" is a crimson red, crumbly, shale containing a few greenish-gray shale beds indicative of a lagoonal environment.

The Grimsby Formation in the Genesee Gorge is a tripartite unit about 55 feet thick containing Arthrophycus allegheniensis. The lower 20 feet and upper 15 feet are coarse, heavy bedded, red siltstones and sandstones with minor amounts of shale. Large scale crossbedding and ripple marks can be found in both divisions. In addition, the upper portion contains blotches, and thin layers of light green to white color. These two subdivisions could be representatives of facies "b". The middle 20 feet is a mixture of thin bedded, red and gray, ripple marked sanstones and siltstones, with prominent interbeds of red and green shale. The middle portion could be a slightly coarser equivalent of facies "c" to the west.

CLINTON GROUP

Lardner Vanuxen (1839, 1842) was the first to use the Clinton as a group name. It is the most fossiliferous widespread Silurian unit and as such has been worked on extensively in an attempt to unravel the complex stratigraphic relationships. In this regard the works of Chadwick (1918); Sanford (1935, 1936); Ulrich and Bassler (1923); and especially Gillette (1947), have been important. Gillette's study of the Clinton Group certainly is the most comprehensive and therefore should form the base for all future research on the Clinton.

Refinements in Clinton correlation, petrology and biostratigraphy have been worked out in Western New York by Rexroad and Rickard (1965) and Kilgour (1963, 1966) and in Eastern New York by Muskatt (1969, 1972) and Zenger (1966, 1971).

Gillette (1947) recognized five ostracode zones in the Clinton Group and related them to Ulrich and Bassler's (1923). This is shown in Table 3. A facies diagram of the Clinton Group and lower Lockport Group is shown in Figure 1.

TABLE III

CLINTON GROUP OSTRACODE ZONES

(GILLETTE, 1947)

	Ulrich and Bassler - 1923	Gillette - 1947
UPPER CLINTON	*Drepanellina clarki* Not Recognized *Mastigobolbina typus* *Bonnemaia rudis*	Not Recognized * *Paraechmina spinosa* *Mastogobolbina typus* Not Recognized
MIDDLE CLINTON	*Zygosella postica* *Mastigobolbina lata* *Zygobolbina emaciata*	Not Recognized *Mastigobolbina lata* Not Recognized
LOWER CLINTON	*Zygobolba decora* *Zygobolba anticostiensis* *Aygobolba erecta*	*Zygobolba decora* *Zygobolba excavata* Not Recognized

*Not recognized by Gillete; found by Zenger 1971. In the west this zone occurs in the lower Lockport.

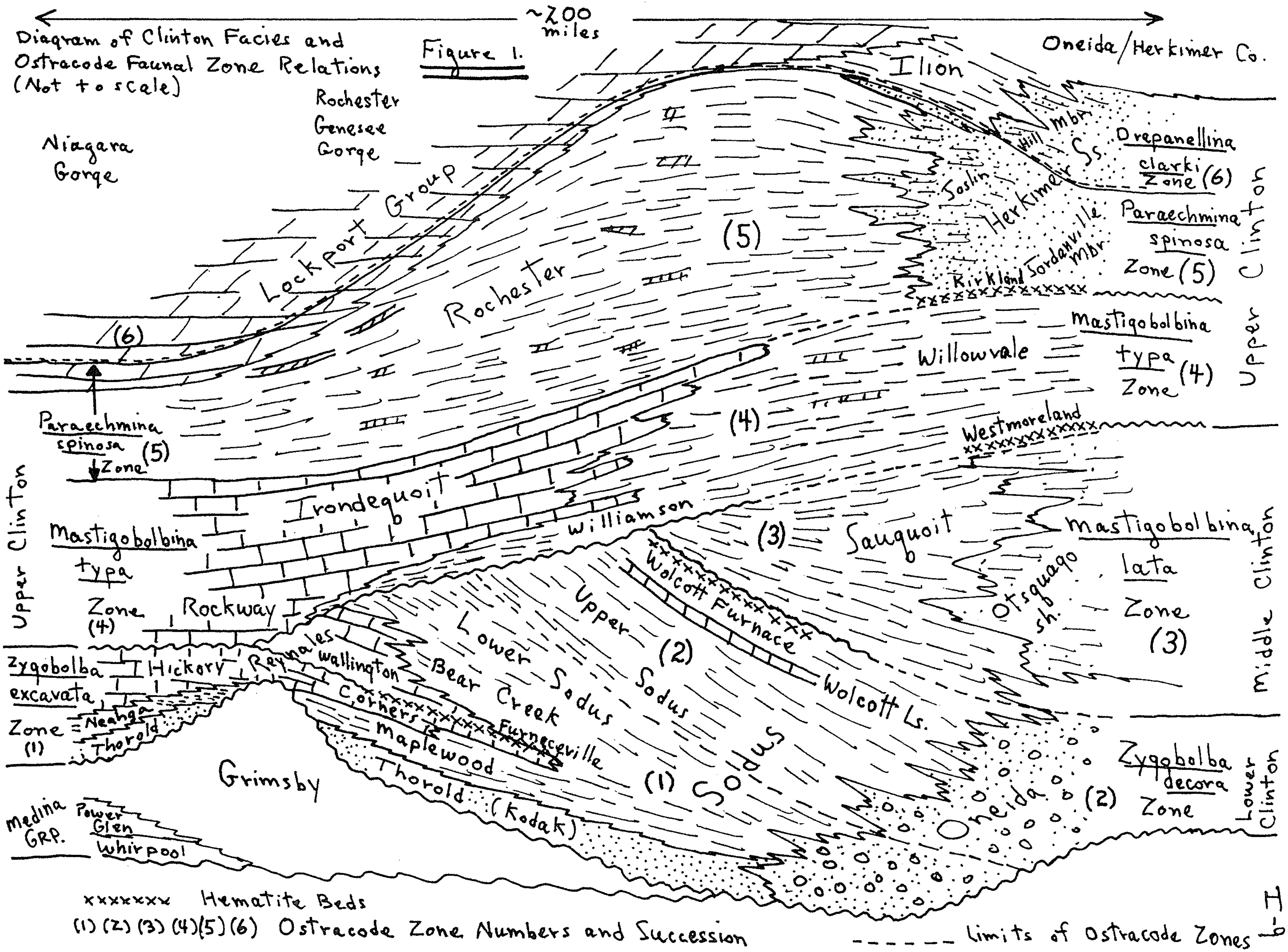


Figure 1.

Diagram of Clinton Facies and Ostracode Faunal Zone Relations (Not to scale)

Thorold Sandstone - Named by Grabau (1913), the Thorold Sandstone is a light gray, to green, fine grained sandstone with a maximum thickness of 5 feet. Once known as the "grey band of Eaton" it is an easily identifiable unit lying above the Grimsby and forming the caprock of the Lower Falls of the Genesee at Rochester.

Although the Thorold is present at Niagara, it is missing for a distance of about 15 miles in the vicinity of Lockport, probably as a result of the Grimsby being an island or peninsula when the Thorold sea was sweeping around two or more sides. This would explain the Thorold pinching out from the east and west.

Chadwick (1935) erected the name Kodak Sandstone for the Thorold at Rochester believing it to be an entirely different physical stratigraphic unit. Gillette (1947) regarded the Thorold as continuous across Western New York State and therefore disregarded the term Kodak. Fisher (1959, 1966) proved that the Kodak was not continuous with the Thorold at Niagara. Furthermore, the absence of any transition upward into the definitely lower Clinton unit (Neahga Shale) led him to place the Thorold in the Medina Group as a facies of the Grimsby. The author thinks that the light sandstone above the Grimsby at Rochester and the light sandstone above the Grimsby at Niagara represent the initial depsit of the same transgressing sea over the Grimsby Sandstone. Although the name Kodak is not necessary, it could be used locally to designate the Thorold at Rochester.

Maplewood Shale - The Maplewood Shale was named by Chadwick (1918) for the 21 feet of smooth, slightly calcareous, green, platy shale overlying the Thorold in the Genesee Gorge. The lower 3 feet is more sandy and calcareous, while several thin stringers of limestones (less than 1 inch) occur in the remaining portion. It is the correlative of the Neahga Shale in the Niagara region. Macrofossils are rare, however, Fisher (1953) reports that it has yielded microfossils.

The Maplewood represents a quiet water deposit in slightly deeper more offshore water.

Reynales Limestone - Initially referred to by Hall (1843) as the "Pentamerous limestone of the Clinton Group", the name Reynales was proposed by Chadwick (1918). It is 17 feet thick and consists of three members, from oldest to youngest as follows: Hickory Corners Limestone (3 feet); Furnaceville Hematite (8 inches - 2 feet); Wallington Limestone (13 feet). The present dam in the river north of the Bausch Bridge covers the Reynales-capped Middle Falls.

The Hickory Corners Limestone is a light gray crystalline limestone with shaley partings, named by Kilgour (1963). It replaces the name Brewer Dock Member of Sanford (1935).

The minute gastrapod Cyclora; the brachipods Hyattidina congesta and Stropheodonta corrugata can be found in this unit. Walliser's (1964) conodont zone of Neospathognathiodes celloni has been found in the Hickory Corners Limestone of the Niagara Gorge by Rexroad and Rickard (1965).

All of the Reynales (4-5 feet) in the Niagara Gorge is referred to as the Hickory Corners Limestone.

The Furnaceville Hematite (Hartnagel 1907) is a thin, lightly variable hematitic limestone. It is a fossiliferous ore, the hematite having replaced the fossil fragments. Round oolites are mingled with fossil fragments, but are more pronounced at some localities than at others. In the Genesee Gorge the oolites are comparatively rare. According to Alling (1947) the oolites contain nuclei of fossil fragments in the west and nuclei of quartz grains in the east.

The origin of the Clinton iron ore beds has been the subject of much controversy. Since the turn of the century, most investigators favor a primary origin for the hematite, wherein, the iron is precipitated on rolling grains of fossil fragments or quartz particles.

The debate seems to be centered around the mineralogical composition of the original iron and the chemistry of the water during precipitation. Hunter (1970) and Sheldon (1970) suggest that the iron was deposited originally as chamosite that subsequently became oxidized, whereas Schoen (1965), believes that hematite was precipitated directly from sea water.

The iron was probably derived from the deep weathering of plutonic igneous rocks in the Taconic landmass to the east. James (1966) believes that warm and humid conditions prevailed at this time. As relief in the source area would decrease, after the Taconic orogenic climax, the intensity and depth of weathering would increase due to decreased mass wasting and stream competency. Hunter (1970) concluded that this is the most important reason for iron rich rocks being deposited in the Clinton Group. During intense tectonic activity, rapid erosion prevents thorough weathering of source rocks and coupled with rapid sedimentation any iron deposition that would occur would be masked. At the opposite extreme, during maximum inundations of transgressing seas, source areas are flooded or nearly so, and therefore not contributing large amounts of iron rich water. Therefore iron concentrated rocks seem to form most readily between times of intense tectonic activity and stability.

Ferrous iron was probably transported to the sea by streams of low Eh and pH although groundwater of similar chemistry may have been partly responsible.

Rapid precipitation of iron resulted when the stream waters entered the somewhat higher Eh and pH waters of the marine basin.

Above the Furnaceville in the Genesee Gorge are about 13 feet of crystalline dolomitic limestone interbedded with layers containing enormous numbers of the brachiopod *Pentamerous laevis*. Fisher (1959) named these limestones the Wallington. Some of the limestones yield the brachiopods *Coelospira hemispherica*, *Stropheodonta corrugata* and *Rhynchotreta robusta*. Thin shale partings are found throughout the unit as well as cherty beds. Ostracodes of the *Zygobolba excavata* zone have been recovered from the Wallington and other members of the Reynales. Gartland (1973) also reports conodonts of the *Neospathognathoides celloni* zone from this unit.

Eastward the Wallington Limestone passes into the Bear Creek Shale (Chadwick, 1918) and eventually into the Oneida Conglomerate (Vanuxem, 1942).

Westward the Wallington corresponds to Kilgours (1963) Merrintton Limestone of the Ontario Penninsula. Neither are present in the Niagara Gorge their position being marked by a major disconformity.

Lower Sodus Shale - The Lower Sodus Shale was named by Gillette (1940) for those Sodus shales carrying the ostracod zone of Zygobolba excavata. The Upper Sodus Shale occurs in the overlaying Zygobolba decora zone. In the Genesee Gorge this unit is marked by a disconformity.

At Rochester, the Lower Sodus Shale is 18 feet thick and consists of green to greenish gray, calcareous, slightly fossiliferous, silty shale with thin (1-3 inches) limestone layers. The basal four or five feet are dominated by less calcareous dark gray or purple shales. In the upper 3 feet there are three prominent layers containing nearly 95 per cent calcareous material. The high calcareous content is due to the layers being composed almost entirely of the brachiopod Coelospira hemisphaerica, thereby resulting in the term "pearly layers" used to describe them. A shell rubble up to 3 inches thick marks the top of the formation in the Genesee Gorge.

The Lower Sodus is a fossiliferous unit of mostly brachiopods (Coelospira hemisphaerica, Stropheodonta corrugata), bryozoans (Phaenopora ensiformis) and bivalves (Ctenodonta machaeriformis, Cyrtodonta alata). Gartland (1973) discovered conodonts of the celloni zone to the top of the Lower Sodus. The true top of the celloni zone is in the Middle Clinton Sauquoit Shale.

Williamson Shale - Hartnagel (1907) proposed the name Williamson Shale for the shales encompassed between the Reynales and Irondequoit Limestones. Chadwick (1918) limited the Williamson to the graptolite bearing shale above the Upper Sodus.

In the gorge the Williamson is about 6 feet of dark green to black, calcareous to slightly calcareous fissile, graptolite-bearing shale, disconformably overlying the Lower Sodus. A few thin limestone beds occur toward the top.

Eastward the Williamson passes into the Willowvale Shale (Gillette, 1947) as does the overlying Irondequoit Limestone. Westward the Williamson grades into the Irondequoit Limestone; therefore its absence at Niagara is due to a facies change.

Monograptus clintonensis is the dominant graptolite; less abundant is the brachiopod Sowerbyella transversalis. Upper Clinton ostracodes of the Mastigobolbina typa zone are present in the Williamson.

Irondequoit Limestone - Hartnagel (1907) named the Irondequoit for the 18 feet of variable limestone, dolomite, and thin dark gray calcareous shales, overlying the Williamson, in the Rochester area. The lower part is more dolomitic and corresponds to Kilgour's (1963) Rockway Dolomite Member in the Niagara Gorge. The Rockway was previously included in the upper part of the Reynales (Zygobolba excavata zone) by Gillette (1947), thereby placing it in the Lower Clinton. However, he specifically never reported any ostracodes from the top of "his Reynales" in the Niagara Gorge; preferring to state (pg. 50) ---"ostracodes are much more abundant (at Rochester) than in the ourcrops to the west" (parenthesis mine).

Rexroad and Rickard (1965) have found abundant specimens of the conodonts Pterospathodus amorphognathoides and Ozarkodina gaertneri thereby confirming Walliser's (1964) amorphognathoides

Zone in the Rockway Member. This zone is known to overlie the celloni Zone, and since the top of the celloni zone is at the top of the Middle Clinton Sauquoit Shale the Rockway must be Upper Clinton and not part of the Lower Clinton Reynales Limestone.

The upper part of the Irondequoit Limestone is a light gray, coarsely crystalline, crinoidal, limestone with thin calcareous shale bands. Crinoid stems, bryozoans, brachiopods, and rugose corals characterize the upper Irondequoit. *Mastigobolbina typa* and associated ostracodes can also be found. Small biohermal masses characterize the upper most portion and arch the topmost beds of the Irondequoit and basal Rochester Shale. This can best be seen on Densmore Creek up from Norton Street.

Rochester Shale - James Hall (1839) named the Rochester Shale for the typical exposures in the Genesee Gorge at Rochester, where it makes up most of the Upper Falls. Here it is 85 feet thick and in western New York is the uppermost unit of the Clinton Group. Except for the lower 10 feet of brownish gray shale, the Rochester is a dark, bluish gray, calcareous, shale with numerous limestone and dolomite layers. Dolomite is more pronounced in the upper 20-25 feet forming the caprock of the upper falls and grading upward into the Lockport Formation. Chadwick (1918) called this upper unit the Gates Limestone. Fossels are most abundant beginning a few feet from the base and extending upward to 15 feet from the top.

It is by far the most fossiliferous unit of the Clinton Group. Some of the more common forms are:

brachiopods
- *Parmorthis elegantula*
- *Sowerbyella transversalis*
- *Leptaena "rhomboidalis"*
- *Rhipidomella hybrida*

bryozoans
    Mesotrypa nummiformsis
    Chasmatopora asperatostriata

cephalopod
    Dawsonoceras annulatum

trilobites
    Dalmanites limulurus
    Trimerus delphinocephalus
    Arctinurus nereus

cystoid
    Caryocrinites ornatus

ostrocods
    Paraechmina spinosa
    P. postica
    Dizygopleura proutyi
    Beyrichia veronica

The Rochester Shale of Western New York properly belings to the Paraechmina spinoza Zone, the uppermost Clinton ostracod zone of Gillette (1947).

Eastward in Oneida and Herkimer Counties, the Rochester Shale passes into the Herkimer Sandstone. Zenger (1971) refined the uppermost Clinton in this area subdividing the Herkimer Sandstone into a western shaly unit, the Joslin Hill Member and an eastern sandstone unit the Jordanville Member. In addition he found the base of the ostracode zone of Drepanellina clarki at the top of the Herkimer which is younger than Gillette's Paraechmina spinoza Zone. This makes the upper part of the Herkimer in the east equal in age to the lower part of the Lockport Formation in the west. The top of the spinosa zone occurs at the top of the Eramosa Dolomite Member of the Lockport. The upper Clinton Group and the base of the Lockport Formation are facies of one another becoming progressively younger eastward.

The Rochester Shale represents a more offshore environment than the Joslin Hill Member, deposited in well oxygenated relatively quiet waters as indicated by the diverse fauna contained therein.

Lockport Group - Hall (1839) designated the section south of Lockport, along the old Erie Canal (present Barge Canal) as the type Lockport. At Rochester the Lockport is a sugary, gray massive dolomite, in places quite sandy. The formation commonly contains vugs of dolomite, gypsum, pyrite, fluorite , sphalerite, and galena. It is approximately 180 feet thick in the Rochester area and being a very resistant unit forms the crest of Niagara Falls, the uppermost part of the Upper Falls at Rochester and the Niagara Escarpment.

Zenger (1962, 1965, 1966) has revised most of the Lockport stratigraphic subdivisions and correlations. Crowley (1971) has worked extensively on the reefs in the Lockport of Western New York.

In the Rochester vicinity the Lockport can be divided into three formations from oldest to youngest as follows: Decew Formation (or Gates Dolomite)20 feet (silty and sandy dolomite); Penfield Dolomite-20 feet (dolomitic sandstone), and the Oak Orchard Dolomite - 140 feet (vugy, massive, stylolitic, dolomite).

Eastward, between Rochester and Syracuse, the Lockport Group is a limestone-dolomite complex separated as the Sconondoa Formation. In the Oneida region the Sconondoa passes eastward into the Illion Shale. The upper part of the Illion interfingers with the lower part of the overlying Salina Group, the contact becoming progressively older eastward.

Fossils are not abundant in the Lockport Formation at Rochester.

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FIELD TRIP I

Stop 1 Lower Falls and Gorge

Down from Seth Green Drive at St. Paul and Norton Streets, on east side of gorge below Driving Park bridge.

Units Exposed

Group	Formation	Member
Lower Clinton	Reynales	Wallington Ls. Furnaceville Hematite Hickey Corners Ls
	Maplewood Shale Thorold Ss.	
Medina	Grimsby Fm.	
	Queenston Fm.	

Stop 2 Middle Falls and Gorge

At the bottom of Brewer St. down from St. Paul Street on east side of river, south of Driving Park Bridge and North of the Bausch Bridge, (Smith St. Bridge)

Units Exposed

Group	Formation	Member
Upper Clinton	Rochester Shale Irondequoit Ls. Williamson Shale	
Lower Clinton	Lower Sodus Shale	
	Reynales Ls.	Wallington Ls. Furnaceville Hematite Hickory Corners Ls.
	Maplewood Shale	

Stop 3 Upper Falls and Gorge

Down from Mill St. and Falls St., on access road to Rochester Gas and Electric Power Stations # 2 & 3, on west of gorge below Platt Street bridge

Units Exposed

Group	Formation	Member
Lockport	Decew Dolomite	
Clinton	Rochester Shale	