The Late Devonian Clastic Wedge in Central New York and Northern Pennsylvania
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This field trip has been designed as a study trip in which the rock sections are discussed and problems for further study are suggested. We will be concerned with what we see in individual exposures, selected to illustrate facies and their origin. Temporal relationships, though well-constrained in the lower part of the section (House and Kirchgasser, 1993), become less so toward the top. Details of temporal relationships in the Fammenian sections are problematic. As a result, concepts of sequence stratigraphy have yet to be applied over much of this section.

We will start with the Tully Limestone and move upsection through black shales, turbidites, fossiliferous sandstone and shales, interbedded red/green and gray strata, and end in coarse sandstones at or just above the Devonian/Carboniferous boundary. Broadly interpreted, the facies represent deeper water marine environments which give way upsection to shallower marine environments, the shore and lowland alluvial plain. Facies sequences seen upsection express Walther's Law within the time intervals that have been sufficiently well deciphered to permit such analyses. That is, deeper water facies are replaced toward shore by shallower water facies. Our predecessors working on these and related sections in Pennsylvania and New York established the patterns over the past century or so.

Insights about the Late Devonian sequences garnered over the past 30 years or so include: elucidation of the physical and chemical processes responsible for these rocks, placement of rock sequences in a plausible time framework and explanations of their regional relationships, facies development in relation to tectonics and paleoclimate, and interpretation of faunas and floras based present-day biology and ecology. Among the next steps will be development of quantitative models of deposition and stratigraphy, more complete outline of temporal relationships, better understanding of paleoclimates, fauna and flora and their relationships to facies development, and development of models of fluid/gas movements.

Stop #1 Kashong Creek, Bellona, New York.

After parking on the west side of the road, we will come into the stream bed from the north, through the woods.

The section in the stream is

Geneseo Shale (above the falls)
Tully Limestone
Windom Shale (below the falls)

This location was the site of a mid-19th century grist mill with its mill-dam. A flood in the 1950's took out the dam and the lip of the falls has retreated somewhat since then. Some of the large blocks downstream of the plunge pool are remnants of the dam. The mill was reroofed about 25 years ago, otherwise the building is mostly a shell. When the mill was active, the low building just south of the bridge over the creek served as the mill office, town store, post office, and a lively dance hall.

The section is typical of those seen at falls on streams tributary to any of the Finger Lakes. The resistant unit, whether it be limestone as seen here or sandstone as seen further east, is surrounded upsection and down by less resistant shale or siltstone. Post-glacial erosion has proceeded at rates controlled by rock-unit resistance and the falls result.

The Tully at this location is gray, fine-grained biomicrite with crinoid fragments as a prominent component. The unit is about 2.5 m thick. Upper and lower subdivisions are recognized within it (Heckel, 1973). The Tully thickens to the east and south of Bellona but it does not extend much further west. West of the Genesee River, the comparable stratigraphic position is marked by the Leicester pyrite. Erosion surfaces bound the Tully top and bottom and mark its internal subdivision.

Below the Tully is the Windom Shale of the Moscow Formation (Brett and Baird, 1994). Gray and fossiliferous at the base, it grades upsection into poorly fossiliferous, black, fissile shale. A prominent erosion surface separates the Windom from the overlying Tully. Above the Tully is the Geneseo Shale, a poorly fossiliferous, black, fissile shale which on freshly broken surfaces, yields a strong petroliferous odor. The Tully/Geneseo is not exposed here but elsewhere is seen to be sharp or gradational over a few cm.

How are we explain the abrupt change from black shale to clean, fossiliferous carbonate followed by a return to black shale? Deposition in relatively deep water seems to be required for the Geneseo given its very fine grain size, laminations, dark color, petroliferous materials, and lack of benthonic or infauna. Its very great areal extent (New York to Alabama and west into the midcontinent as part of the Chattanooga Shale sequence) suggests deepening in response to eustatism (Johnson, Klapper and Sandberg, 1985). Acadian tectonism to the east provided the siliciclastics found in the Geneseo and probably contributed to the deepening.

The Tully at this location, on the other hand, represents a time of reduced siliciclastic influx and increased deposition of primarily biologic carbonates. Heckel (l973) explained the reduced clastic influx to the Tully deposites in New York by postulating a fault-bounded uplift further east. Alternatively, Brett and VerStraeten suggested that the uplift might be a foreland bulge (reported in Heckel, 1997, p.80). Whatever the explanation for the lack of clastics in the Tully, a rapidly subsiding basin existed to east in New York. The easterly basin trapped enormous volumes of sandstone and shale represented, for example, in southeastern NY and northeastern Pennsylvania by the Sparrow Bush Sandstone (Woodrow and Fletcher, 1972). The basin filled rapidly and the boundary uplift was overwhelmed, spilling finer sediments to the west and flooding the Tully depositional surface and forming the Geneseo Shale as sea level rose.

Stop #2 Watkins Glen State Park.

<u>THIS IS A HARDHAT LOCATION.</u>

Vertical cliffs about 50 m high bound the stream draining from the narrow mouth of Watkins Glenlls. In the cliff are exposed medium gray, fine-grained sandstones and dark gray, silty shales of the Penn Yan (and West River?) Shales of the Genesee Group. With the Geneseo below, these rocks and the younger Devonian rocks above form a basin-fill about 2000 m thick in this region, of which all but a tiny percentage is siliciclastic

Exposures of the Group are available at many other locations around the south end of Seneca Lake. These rocks represent extend, at approximately the same elevation, from north of Watkins Glen south to Montour Falls village where they are exposed in a falls. The Fir Tree Point anticline crests about 4 km north of Watkins Glen and this fold disrupts the regional southerly dip of a degree or less and renders the sequence nearly horizontal for a north/south distance of at least 10 km.

Watkins Glen village has long been the site of salt production and tourism and, occasionally, disastrous flooding. Two companies are presently extracting salt by solution from the Salina Group about 700 m below ground. Tourists come to WGSP and its campground, the Glen auto-racing track on the hill above, the nearby wineries, and Seneca Lake. Few people, however, are aware of the flooding potential posed by the creek which flows through WGSP, Watkins Glen village and into the adjoining marsh. The stream flows out of the Glen on to the alluvial fan on which the village is built. This means that much of the village is subject to the sedimentary processes associated with fan development. An example: on a summer evening in July, 1938, 7-8" of rain in a few hours time resulted in a mass of water, mud, boulders, tree trunks, pieces of railroad bridge and other flotsam plugging the Glen mouth and then bursting out on to the town. In the resulting flood, one person died, several houses were destroyed, and much of the village suffered damage. Major flooding events look to have about a high recurrence at intervals of about 30-50 yrs and are little thought about in the interim.

The sandstones and shales in this exposure are arrayed in cm-scale fining-upward sequences. Body fossils are extremely rare but there is scattered plant debris and some bioturbation. The sandstone beds are sharp-based with their basal surfaces marked by groove casts and rare, flutes. The sandstones are fine- to medium-grained at the base, some contain shale chips, and they fine upwards to siltstone and shale. Well defined small-scale and steep cross-strata, some arrayed as climbing ripples, are found at the base of individual beds with larger-scale, low angled cross-strata at the top. Sandstones grade into shales at the top of each couplet.

The sequence looks to be a stack of turbidites made by dilute, relatively slow-moving and lightly erosive density currents. No complete turbidite sequences are found in these exposures. Most are based on Bouma subdivision "c" and a few are based on subdivision "b." (Bouma, 1962; Isley, 1981; Woodrow and Isley, 1984). As differentiated by color in the cliff face, it is apparent that there are 3-5 m thick, repetitive sequences, probably fifth-order sequences or cyclothems.

It should be noted that the sequences in and near WGSP are typical of those seen in this facies in the Late Devonian of New York and Pennsylvania which strongly suggests that the Late Devonian sea floor in this region was of low, steady gradient. Abrupt changes in gradient were the exception, not the rule. This interpretation is based on the absence of channeling, slump scars, slumped masses and thick "slope muds," all typical of modern-day continental slopes. That channels are rare in this sequence is demonstrated by their being only a single channel-fill in rocks of this facies known to this writer and that is exposed along I390 south of Danville, NY (Kirchgasser, Over, and Woodrow, 1997). Further, sediment transport and deposition on a low-gradient ramp would explain the weakly erosive turbidity currents responsible for the turbidites seen here.

Stop #3 Cowanesque Dam Spillway.

THIS IS A HARD-HAT LOCATION.

PERMISSION TO VISIT THIS AND THE TIOGA/HAMMOND DAMS MUST BE OBTAINED FROM THE US ARMY CORPS OF ENGINEERS AT 570-835-5281 OR 570-827-3143.

Completed in 1980, the Cowanesque dam, like the Tioga/Hammond dams to the south, is mainly a flood-control structure. Construction of the three dams was impelled by devastating hurricane-related flooding in 1972. Exposures resulting from the construction of the three dams plus those along US 15, a rerouted railroad and local streams provide the most complete and extensive late Frasnian sections in this region. The exposures presently available will be added to by new exposures along US15 in NY and PA as it is upgraded to interstate specifications. The Tioga gas-storage field underlies the hills between the Cowanesque and Tioga/Hammond dams and data from the wells drilled in it will provide further insights into the local stratigraphy. A well in the Tioga gas field provided samples which constitute the type section of the Middle Devonian Tioga Bentonite.

At Cowanesque, the stratigraphic position of the rocks is latest Frasnian (pre-Dunkirk Shale) equivalent to the Wiscoy Sandstone of New York. The Pennsylvania Geologic Survey places these rocks in the Lock Haven Formation. Without more detailed mapping and work on the fossils, more confident temporal placement of these beds is not possible.

At the spillway is a 60+ meter section made up of medium-grained sandstones and gray, silty mudstones and shales. A stratigraphic section will be provided on the trip. Thickness of individual sandstone beds varies from a few cm to a meter. Cross-strata occur at many scales in the sandstones and some are hummocky. Mudstones are heavily bioturbated. The finer grained rocks contain many fossils, mostly brachiopods. Bone fragments and plant debris are found scattered through the section.

These strata represent shallow-water marine environments. Waves effects are apparent in the sandstones and the diverse epifauna and infauna indicate shallow water as well. Red strata are about 100 m upsection and to the southeast, toward the ancient shoreline, red strata are developed in this interval within 50 km of this location.

In the cliff above PA 49 (and inaccessible to us) are several, 5-8 m thick bodies of medium gray, medium- to coarse-grained sandstone. They rest on strata like those seen in the spillway and are taken to be distributaries or distributary-mouth bars built on to a muddy sea floor.

Alternative to Stop #4. PA rte 287, about 2 km west of Tioga village.

THIS IS A HARDHAT LOCATION.

This is one in a group of a closely-spaced exposures found along the RR track below rte. 287, on both sides of rte. 287 and on both sides of the access road from rte. 287 to the Hammond Dam Overlook on the hillside above. About 75 m of section are available here. If the trip visits this location, sections on the north side of rte. 287 and the Overlook access road will be examined.

These are highly fossiliferous sandstones and shales. A bed of rugose corals is found at the base of the section. A meter-thick sandstone, granule-bearing sandstone about 15 m above the base of the section has in it well preserved bivales and spiriferid brachiopods. Brachiopods and bivalves are common in the higher strata and are the predominant feature in some beds. Ball-and-pillow structures occur in reddish-gray sandstones toward the top of the section.

By projection, these strata look to underlie those seen in the Connecting Channel (and those at stop #5) by about 100 meters. The relationship oft these strata to those exposed at the Cowanesque Spillway is uncertain but if both sections are pre-Dunkirk then their stratigraphic positions may be comparable.

Stop #4 Tioga Dam and connecting channel.

THIS IS A HARD HAT LOCATION.

PERMISSION TO VISIT THIS SITE MUST BE OBTAINED FROM THE US ARMY CORPS OF ENGINEERS AT 570-835-5281 OR 570-824-3143.

We will look first at the section as it is exposed on the south side of the Connecting Channel and, depending on time, proceed down the access road to examine the "white bed" and the rocks immediately above and below it. A stratigraphic sequence will be provided at the trip. We will then walk through channel to look at very large burrows in red strata thought to be estivation tubes of lung-fish and to see what is thought to be the Center Hill ash bed.

This section, and the one like it on US 15 overlooking the dam and about 2 km east of it, spans the Frasnian/Fammenian boundary. (A column will be provided at the trip.) It also documents the marine to nonmarine transition. Starting at the base is a sequence of fossiliferous, darkgray shales and sandstones. In the dark gray shales near the base of the section is what appears to be a bed of ash, perhaps the equivalent of the Center Hill Ash Bed (Wahler, 1984). Between the dark gray shales at the base and thinner gray shale and sandstone sequence above is a thin red sequence exhibiting mudcracks and what appear to be lungfish aestivation burrows. A light-gray sandstone referred to informally as the "white bed" is just above the second gray unit, about 10m above the red bed. Above that, gray, fossiliferous strata return and those give way upsection to red beds many tens of meters thick. Fish material is common in the uppermost red beds.

This is clearly the record of a shoreline without a beach. Instead, the sequence appears to represent a low- relief, muddy shore protected from wave attack by sand bars (white bed) just offshore.

Alternate stop #4. Roadcut, PA rte 287, west of Tioga village.

Three separate, but closely spaced exposures: along a railroad, on both sides of rte 287 and along road to the Hammond Dam Overlook, provide access to about 75 m of section. A stratigraphic section of the road exposures will be provided on the trip.

The section is made up of medium grained sandstones and gray silty shales with many fossils throughout. Notable strata include: a bed of rugose-corals near the base, two quartz granule-bearing sandstones about 15 m higher, profusely fossiliferous strata about 15 m above that and ball-and-pillow structures in dusky red, fine-grained sandstones near the top. Brachiopods, bivalves, and crinoids are the most common fossils.

Knowing the stratigraphic position of these strata is difficult. Projecting them across the valley to the Connecting Channel suggests that they are 100 m lower than the rocks seen there. That would make them Late Frasnian, a position in accord with finding rugose corals. Those corals are a well-known feature in Frasnian strata in New York.

Stop #5 (optional). Roadcut, US 15 overlooking the Tioga Dam.

THIS IS A HARDHAT LOCATION.

This section duplicates most of what is seen at Stop #4 except that the section is less well exposed over much of its extent and the din and danger of heavy traffic is constantly in evidence. However, the section is available for study at any time with no permission needed.

Stop #6 (optional). Roadcut (new), US 15 at Blossburg, PA.

THIS IS A HARDHAT LOCATION.

This section has been recently opened as part of the upgrading of US 15. A stratigraphic section will be provided at the field trip. The main feature of the base of this 100+ m section is medium- to coarse-grained sandstones arrayed in 10 m thick, cross-stratified, fining-upward sequences. A 5m thick, very fine-grained gray shale occurs mid-way up the section with red strata and light-gray sandstones at the top. The shale may mark the base of the Carboniferous. Results from a study of miospores study may be available at the time of the trip as a test of this this hypothesis.

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ROAD LOG

Distances are approximate

0.0	Parking lot, Scandling Center, Hobart and William Smith Colleges, Turn left (s) to Pulteney St.
0.3	St.Clair St. Turn right (w).
0.8	White Springs Road. Turn left (s).
2.1	Snell Road. Turn right (w).
3.2	Snell Road veers to the right.
3.7	Preemption Road (Ontario County Rd. 6)
8.0	**Stop #1, Kashong Creek, Bellona, NY.** Park where convenient. Be certain not to block the Fire Department driveway. Leaving Bellona, proceed right (s) on Preemption Road.
8.3	Earl's Hill Road. Turn left (e) toward Seneca Lake.
10.3	NY rte 14. Turn right (s).
38.1	**Stop #2, Watkins Glen State Park (WGSP), Watkins Glen, NY.** Park in the parking lot along the creek bank. Do not enter stairway to Glen. Leaving WGSP, proceed right (s) on NY 14.
38.8	Junction of NY 414 and NY 14. Veer right (s) on NY 414 toward Corning.
57.8	Junction with NY 17 (I86). Turn right (w). Road Cut on right is of the Frasnian West Falls Group. Sequences with shale at the base grading upsection through 5-10 meters to lighter gray sandstones, some containing corals. Leslie (1999) has described the lower part of this poorly accessible exposure.
60.7	Junction with US 15. Turn left (s).
73.8	Lawrenceville, PA. Turn right on PA 49. Cowanesque Dam is visible straight ahead.
76.1	**Stop #3. Cowanesque Dam, Lawrenceville, PA.** Pull off the road and walk downhill on the dirt access road. Exposures in spillway, cliffs below and above road. Leaving Cowanesque, proceed left (e) on PA 49.
78.9	Lawrenceville, PA. Turn right (s) on US 15.
83.3	Junction of US 15 with PA 287. Go straight ahead on PA278.
85.6	Tioga, PA. Junction of PA 278 with South Main St. Continue straight ahead (s) on South Main St.
86.0	Turn right (w) on Channel Overlook Access Road.
87.3	**Stop #4. Tioga/Hammond Dams connecting channel.** Sections are available here along the various access road and in the channel proper. **Be very careful as we walk on the paved ledges beside the channel.** These rocks appear to span the Frasnian/Fammenian boundary. Gray, marine rocks are at the base of the section and

red beds are found at the top. Leaving the Channel Overlook, return via access road and S. Main St. to junction with PA 278.
[Note: If the weather is bad, we will forego the Tioga/Hammond Dams Connecting Channel and go, instead, to a major exposure on PA 287, about 2 km west of Tioga Village. This exposure is the first one west of the village the right (n) side of rret 287.]

88.9 Junction with PA 287. Continue straight ahead on 287.

90.6 Junction with US 15. Turn right (s) on 15 for two optional stops.
Optional stop #5. Roadcuts on US 15 east of Tioga Dam. This section duplicates much of what is seen at stop #4, however, much of the section is not well exposed along the highway. The red beds at the top of the section are more readily accessible here as is the sandstone/shale section at the base.
Leaving Stop #5, proceed south on US 15 to see optional exposure #6.

112.6 **Optional stop #6. Roadcuts on US 15 at Blossburg, PA.** This section is new and has not been examined in detail. The lowermost strata are thought to be latest Devonian with the Devonian/Carboniferous boundary higher in the section. The coarse grain size of the sandstones, presence of non-persistent sandstone bodies as much as 10 m thick, rarity of gray strata, presence of channel-fill cross-strata and lack of body fossils and bioturbation all suggest that these rocks are non-marine.
Leaving Blossburg,, turn left (N) on US 15. Return to Geneva via US 15 to Corning, NY 17 east to NY 414, NY414 to Watkins Glen and NY 14 to Geneva.

195.8 Scandling Center parking lot, Geneva, NY.