MARINE AND FLUVIAL DELTA PLATFORM ENVIRONMENTS OF THE TRANSGRESSIVE CLASTIC CORRELATIVES OF THE MIDDLE DEVONIAN (ERIAN) MOTTVILLE LIMESTONE MEMBER OF THE SKANEATELES FORMATION IN EASTERN NEW YORK STATE

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INTRODUCTION:

In west-central New York, the base of the Skaneateles Formation is in arenaceous limestone and coquinite designated by Smith (1916) as the Mottville Limestone. When traced eastward toward Kingston, N.Y., this unit and the associated calcareous siltstones thicken and grade into lenses of calcareous, planar crossbedded sandstones and dark gray laminated and bioturbated shales and coquinites, without the diagnostic faunal correlatives (Grasso and Wolff, 1977).

The sequence is interpreted as a zone of carbonate deposition (organic and inorganic) formed on the marine delta platform during a temporary clearing of the Proto-Atlantic seaway. Eastward this clearing produces a short transgression enabling a reworking of the sandy sediments on the marine delta platform to produce a series of offshore and nearshore sand bars and associated embayments. A major embayment located between two nearly-merging lobes of the alluvial delta platform forms an area of practically restricted circulation producing a variety of shallow water environments (nearshore and river mouth bars, sand flats, channels, beaches) and restricted environments (irregular shelf ponds, lagoons, mudflats, interdistributary bays and swamps). These "transgressive" sediments are abruptly truncated by a sequence of gray "channel" sandstones and "overbank" olive-green to maroon silty shales - the return of distributary progradation as the rivers of the classic Catskill Delta Complex once again spill their sediments across the subsiding basin.

This field trip will examine the transgressive and restrictive nature of the marine sediments that are wedged between the initial redbeds of the Catskill delta. Some of these stops and environments described here have also been described elsewhere. (Buttner, 1968; Wolff, 1969; Pedersen, Sichko, Wolff, 1976)

PREVIOUS WORK

The earliest studies of the Middle Devonian strata in this region, described as the "Hamilton Group", date back to the work of L. Vanuxem in his report of the "Third Geological District" for the newly conceived N.Y. State Geological Survey (1842). The sequence was reexamined by Darton (1894) who included the Skaneateles and Marcellus Formations in the Hamilton Group, and by Prosser (1895, 1899) and Grabau (1906) who subdivided these Formations but provided erroneous correlations. Cooper (1930,1933) clarified the subdivisions across the state, and aided Goldring (1935, 1943) in tracing these subdivisions eastward from the Schoharie Valley. Wolff (1969) presented a simplified nomenclature for these subdivisions, but the lack of definitive biostratigraphic criteria for correlation has prevented their acceptance. This nomenclature has since undergone further modification after more extensive field investigation. (Pedersen, Sichko, and Wolff, 1976; Grasso and Wolff, 1977)

Once the time-stratigraphic regional correlations of the Catskill Delta were firmly established for the Middle Devonian Hamilton Group (Cooper, 1930, 1933) and the Upper Devonian sections (Chadwick, 1933) more detailed correlations and sub-environmental discriptions were possible. It became recognized that the thick wedge of coarse clastic sediments spread across N.Y. and Pennsylvania is constructed within a thin but widespread series of stratigraphic markers that are lithologically distinct and that do not change facies as rapidly as adjacent strata. During the Upper Devonian, it is the black shales that cut through the various deltaic phases as marker beds (Richard, 1964; Sutton, Bowen and McAlister, 1970). These were interpreted as short-lived pulses that produced regional stagnation and restricted circulation, and that separated the Catskill Delta into 5 overlapping progradational sequences (Wolff, 1965).

During the Middle Devonian period the stratigraphic marker horizons are limestones and calcareous sandstones (McCave, 1968, 1973; Johnson and Friedman, 1969) that can be traced eastward into their transgressive clastic correlatives. The purpose of this trip is to examine the initial sequence that provided the characteristic patterns of shallow water, high energy, and restricted circulation - patterns that would later be used to subdivide and identify the environments of the Catskill Delta Complex (Friedman and Johnson, 1967).

REGIONAL STRATIGRAPHY:

As designated by Smith (1916, 1935) the Mottville Member at the base of the Skaneateles Formation consists of 0.3 meters of limestone (biomicrite) at the type section in the Skaneateles U.S.G.S. 7½' quadrangle. The unit is found associated with underlying fossiliferous and calcareous siltstones and shales. This lithology and association persists eastward toward the Chinango Valley where a 0.2 meter coralline and crinoidal limestone appears, and where the entire unit represents and interval of 16 meters. Eastward the limestone and associated shales can be traced to the Unadilla Valley (west of the field area) where it grades into a section of mega-rippled and planar crossbedded sandstones and calcareous shales. As a limestone, the Mottville Member makes its last appearance; as a calcareous crossbedded sandstone with a diagnostic marine fauna, it makes its last eastward appearance in the Susquehanna Valley (west of this field area) - Grasso and Wolff, 1977). However, the lithologic associations and marine fauna persist eastward into Richmondville and (finally) into the Schoharie Valley where it will be viewed on this trip. The diagnostic fauna (now limited to coquinite horizons) with the large brachiopods Mediospirifer and Paraspirifer have not been found - thus the use of the term "clastic correlatives". Based on the sediment facies and stratigraphic nomenclature established by Fisher and Richard (1975) the various members of the Marcellus and Skaneateles Formations have been placed into the deltaic environments of Figure One.

The Marcellus and Portage facies, which represent the seaward basin and distal delta slope environments are found west of this area at this interval, and will not be observed. In eastern N.Y. the Hamilton facies is represented by the Otsego and lower Mt. Marion Members. These units consist of dark gray shale, burrowed mudstone, and interbedded light gray siltstone and sandstone, 2-4 cm. to 0.9 meters thick. These sandstones become thicker and coarser higher in the section, and frequently contain "ball and pillow" structures. In addition, they contain a moderately diverse benthic and epipelagic fauna of brachiopods and pelecypods.

The Chemung facies (represented by the Solsville, Panther Mt. and upper Mt. Marion Members) consists here of medium-grained sets of planar cross-bedded sandstones with flat or megarippled basal contacts interbedded with horizontal sandstones (flagstones) siltstones and dark shales. Characteristic structures include: low angle planar cross-bedding, scour and fill pockets, current lineation, oscillation or current ripples, lateral and vertical burrows, horizontal laminations and wavy or flaser bedding. Coquinites, pebble beds plant fragments, and shale clasts also occur in certain units.

The Catskill facies, represented by the Ashokan and Plattekill Members, consists of olive-gray, olive-green, and maroon-red siltstones and mudstones, truncated by thick sets of medium-coarse grained gray planar and trough crossbedded sandstones. The location of the field trip stops within each of these members is indicated in Figure Two.

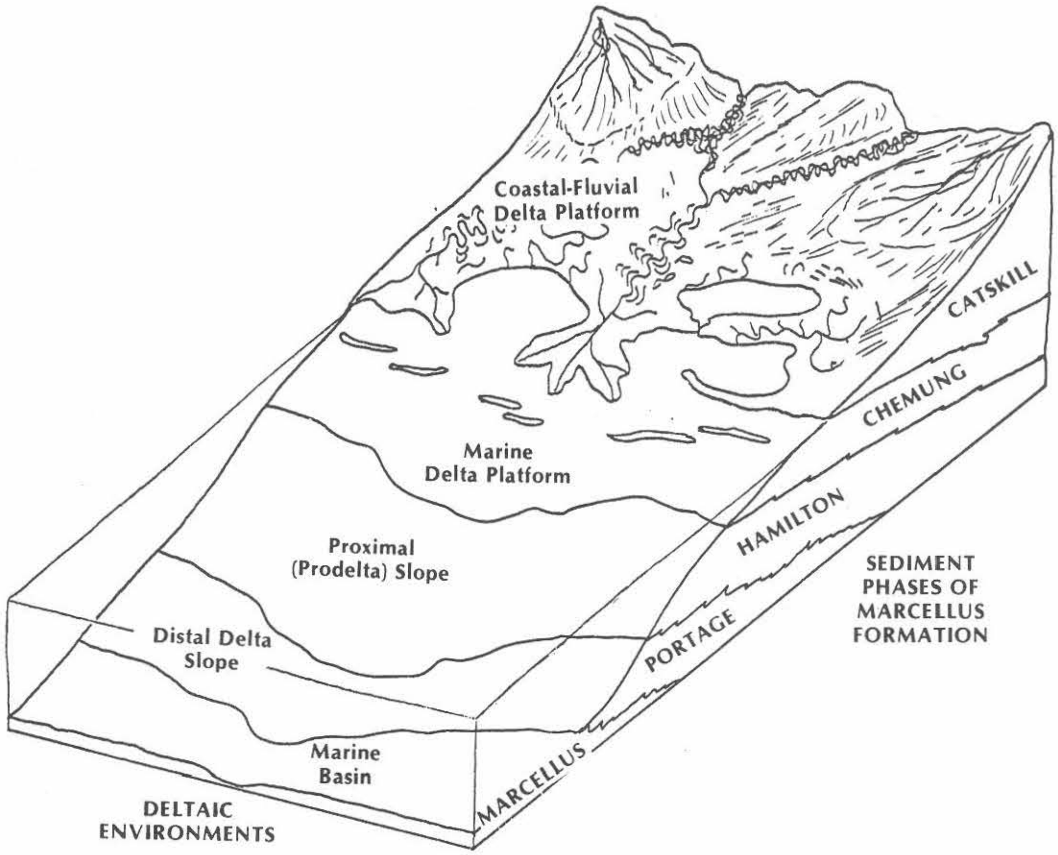


Figure 1. Depositional phases of the Devonian "Catskill Delta Complex" and this associated deltaic environments within the Marcellus and Skaneateles Formations.

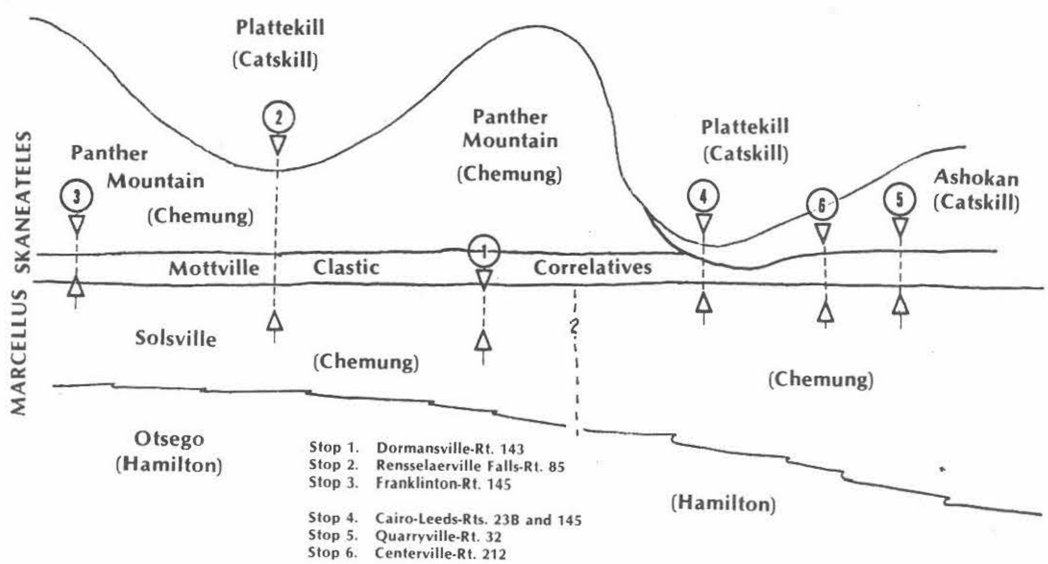


Figure 2. Correlation of the Mottville Clastic Correlatives between the various Members of the Marcellus and Skaneatles Formations and their associated depositional phases.

The Mottville clastic correlatives can be recognized in all of these facies. The calcareous, planar crossbedded sandstones pinch out into blue-gray siltstones and shales with wavy or horizontal lamination and are also underlain or overlain by interbedded rippled and bioturbated sandstones and dark gray shales. The megarippled sandstones initially appear as wide lenses, with bimodal (onshore-offshore) dipping planar crossbeds west of this area. The appearance of laterally equivalent sandstones and shales suggests an environment of shoals with sandbars producing a more restricted but still shallow water environment for the interbedded sandstones and shales of the marine delta platform (see Figure 3).

LOCAL STRATIGRAPHY AND PETROLOGY:

West of the area covered by this field trip, near Otsego Lake and on the east side of the Unadilla Valley, the Mottville Member consists of 3-3.5 meters of bioturbated, cross-bedded sandstone with a few brachiopod coquinites containing Mediospirifer and Paraspirifer. These were

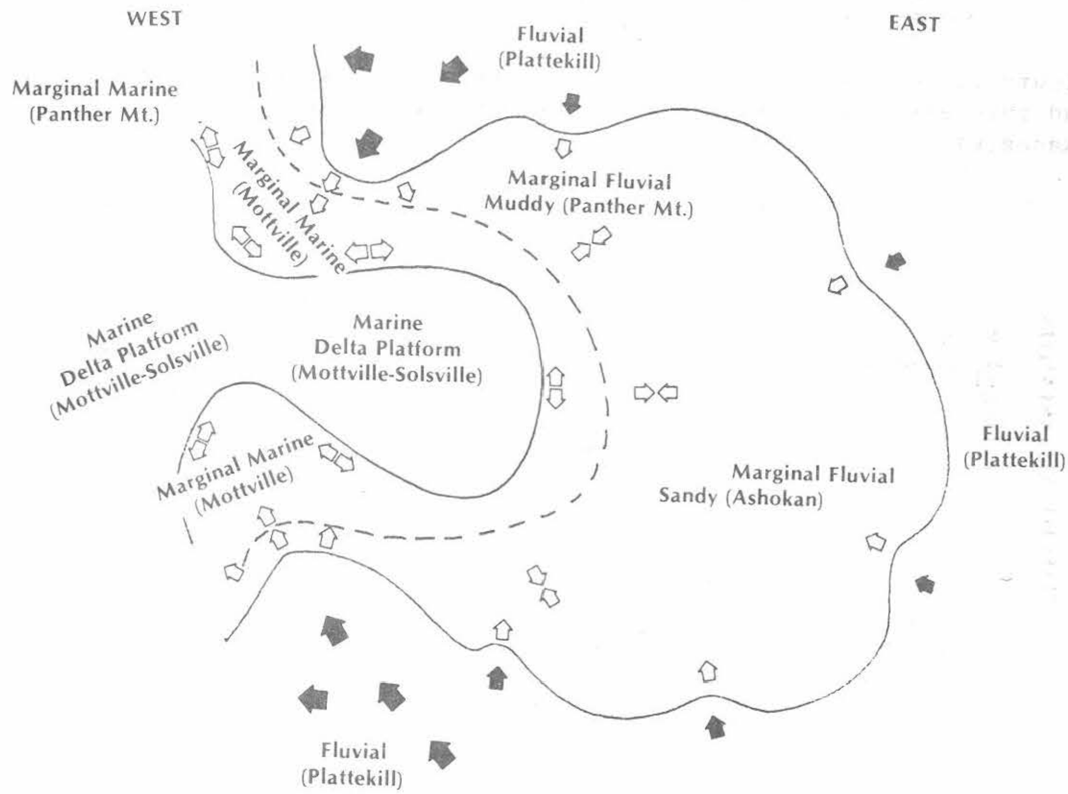


Figure 3. Schematic representation of the sediment environments and paleogeography associated with the members of the Mottville Clastic Correlatives. (Arrows indicate direction of sediment transfer).

interpreted as delta front sand deposits, reworked on the distal delta platform (Grasso and Wolff, 1977). While the open seas promoted some winnowing of the delta front sands to produce local shoals, the suspended silts and muds were deposited as rippled and cross-laminated deposits with coquinites in partially restricted irregular troughs or ponds between the shoals (see Figure 4). The platform sands provided barriers that restricted coastal circulation and their later lateral migration, across the silts and muds provided for local small scale ravinement - similar to the recent erosion or ravinement of lagoonal deposits in front of migrating barrier islands (Wolff, 1975). Similar associations occur near Richmondville, just west of the area viewed on this trip; here the megarippled, bioturbate sandstones form the Solsville and Panther Mt. Members - the Mottville clastic correlatives between them are difficult to distinguish, but can be determined by their content of quartz cement and slightly improved sorting.

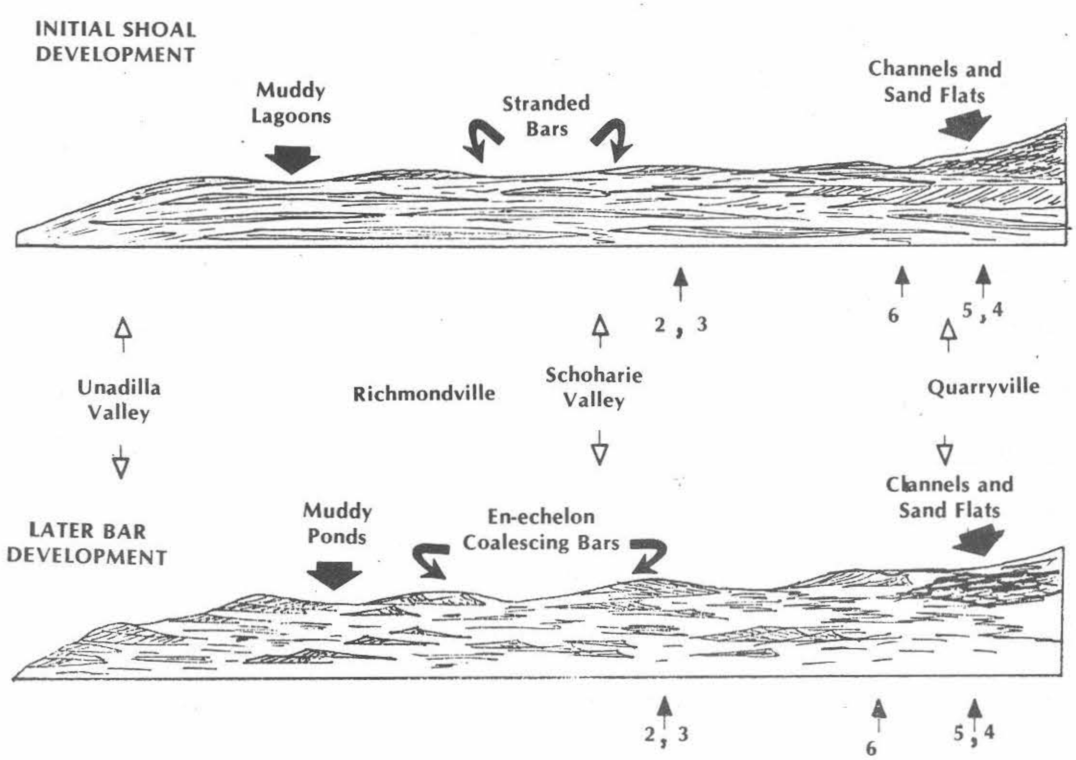


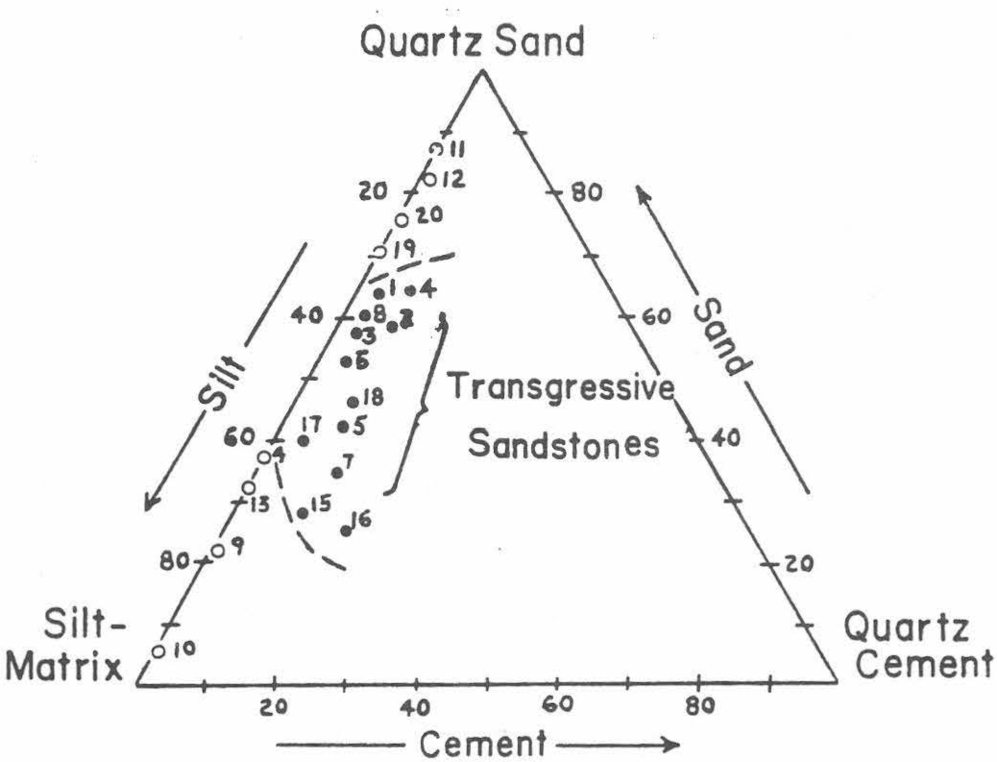
Figure 4. Progressive development of sandy shoals into lenticular migrating sand bars and the formation of the associated irregular muddy ponds by small scale migration and ravinement on the marine delta platform.

Besides the lithologic association across the marine delta platform the faunal indicators change from one of moderate diversity (Camarotoechia community) on the distal end to one of high diversity (Rhipidomella and/ or Limoptera community) on the proximal side (Grasso and Wolff, 1977). This high diversity association occurs just above the Mottville throughout the region and is characterized by abundant sessile epifaunal and infaunal filter feeders, non-sessile epifaunal filter feeders, and vagrant benthos forms. Along with the coquinites and bioturbation the assemblege suggest sediment redistribution and high current activity. The abundance of filter feeders indicates that a substantial amount of suspended organic detritus had to be available for them - an environment of lenticular sandy shoals separated by deeper partially restricted irregular shaped ponds and lagoons across a wide embayment also seems appropriate (see Figure 4). This also explains the lack of the characteristic open marine fauna representative of the Mottville Member on the prodelta slope - these species avoid the partially restricted environments of the delta platform.

East of the Schoharie Valley the crossbedded megarippled sandstones associated with the Mottville Member become more asymmetric and "bar-like" with a gently inclined seaward slope (2-5^{o}), a steep landward slope (6-17^{o}), and unidirectional crossbeds trending westward or southeastward. The overlying shales contain a diverse marine fauna, but they become sparse and diminutive eastward, and are replaced by fine grained sandstones that contain brackish-water ostracods (Beyrichia) and phyllopods (Esthyria membranacea). At Rensselaerville these units grade into 11 meters of mottled red-green siltstone and shale. This section thus demonstrates the change from nearshore restricted marine conditions (Mottville Member) into a brackish embayment (Panther Mt. Member), and the gradual infilling of this interdistributary bay by overbank and floodplain strata (Plattekill Member). This embayment persists throughout this region as a more open but slowly subsiding basin (Albany Bay of Goldring - 1935). The underlying Marcellus Formation thickens from 270 meters in Richmondville to nearly 400 meters in this region; instead of bar-like shoals the subsiding embayment is represented by thick lenticular sand bodies and coquinites.

Southeast of the Catskill Mts. the Mottville Member is again represented by the calcareous sandstones that appear in the Schoharie Valley; rimming the south side of the embayment. The rippled and laminated crossbedded sandstones are interbedded by bioturbated sandstones and shales. The overlying strata of planar and trough crossbedded sandstones with abundant mud clasts, scour and fill structures, and plant fragments - all suggesting intertidal conditions and the appearance of marginal channels and river mouth bars (see Figure 4).

In the absence of diagnostic faunal criteria these clastic correlatives can be distinguished from adjacent strata by their petrologic characteristics. Westward from the Schoharie Valley the lenticular megarippled sandstones are calcareous, light gray in color, with observable quartz cement. They can therefore be distinguished from somewhat similar sandstones within adjacent strata (Solsville and Panther Mt. Members) which have less quartz cement (see Figure 5). As a check, a similar pattern was determined for other transgressive, reworked calcareous delta platform sandstones in the Portland Pt.-Cooksburg and Tully-Laurens Members of the Hamilton Group. Southward, between Dormansville (Stop 1) and Kingston, these petrographic criteria are still consistent. In addition, the appearance of asymmetric en-echelon sandbars at one persistent interval (used for this analysis) between the interbedded marine shales and sandstones and the crossbedded gray sandstones associated with olive-green and maroon shales are taken to represent the continuation of the Mottville Member (Wolff, 1969).



Petrology of transgressive marine and alluvial delta platform sandstones of the Hamilton Group in the Oneonta-Kingston area. (250 counts/slide measured perpendicular to bedding)

Figure 5

Stratigraphic Member (Sandstone)	Location
1. Gilboa (Tully)	1. Rt. 30 N. of town of Grand Gorge
2. Gilboa (Tully)	2. Reed Hill Quarry, NE of Schoharie Reservoir
3. Cooksburg (Portland Pt.)	3. Rt. 30, S. of town of Blenheim
4. Cooksburg (Portland Pt.)	4. Rt. 30, S. of town of Blenheim
5. Mottville correlative	5. Rt. 145 at town of Franklinton
6. Mottville correlative	6. Glasco Tpke. below Kingston Reserv.
7. Mottville correlative	7. Rt. 28, E. of town of West Hurley
8. Mottville correlative	8. Rt. 28-A, near town of Stony Hollow
9. Ashokan	9. Rt. 28, near Stony Hollow
10. Ashokan	10. Schoharie Co.Rd.#54 at "Zucks Corners"
11. Ashokan	11. Rt. 32, town of Quarryville
12. Plattekill	12. Rensellaerville Falls, town of Rensellaerville
13. Plattekill	13. Rt. 32, town of Quarryville
14. Plattekill	14. Rt. 23, town of Palenville
15. Mottville correlative	15. Button Falls, Rt.8, Unadilla Valley
16. Mottville correlative	16. Otsego Co.Rd.#51-Plainfield Ctr.Quarry
17. Mottville correlative?	17. Off Rt. 20, Twelve Thousand Quarry, Otsego County
18. Mottville correlative?	18. Leatherstocking Falls off Rt. 28
19. Solsville	19. Rt. 10, Richmondville
20. Solsville	20. Rt. 10, Richmondville

The bimodal northwest-southwest crossbeds and current lineation are also associated with a northeast-southwest series of smaller planar crossbeds and cross lamination. The latter suggest the influence of a longshore component operating along the marginal edge of the embayment as well as an onshore-offshore sand transfer system (see Figure 6A). In comparison, the marginal and fluvial channels, with their scour and fill structures, small scale planar and trough crossbedding, and fining upward textural sequences all display a predominant northwest current component with a secondary northeast trend, suggesting a fluvial or peritidal sand transfer system (see Figure 6B). When taken together the physical stratigraphy, paleoecology, sedimentology and petrology all suggest a paleogeography that was dominated by a shallow, locally subsiding, but well agitated and partially restricted marine delta platform, with linear shoals and embayments.

FIGURE 6B

Current Indicators
Ashokan-Plattekill Members

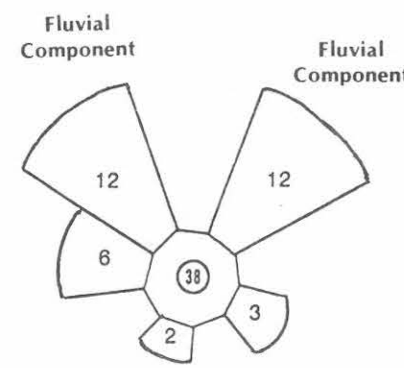


FIGURE 6A

Current Indicators
Mottville Member

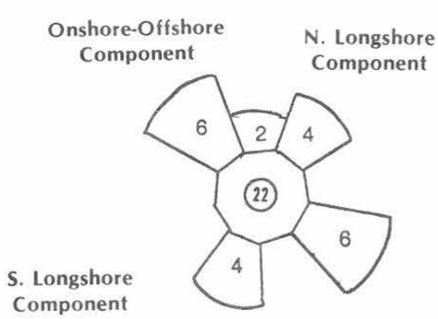
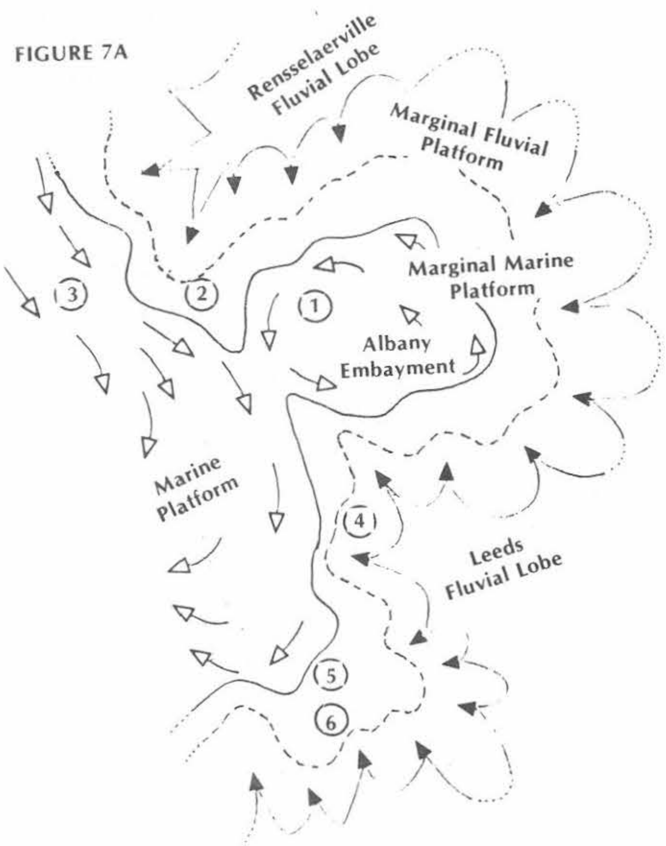


Figure 6. Current vectors for crossbedding and current lineation structures between the Mottville Clastic Correlatives and adjacent members on the eastern side of the Appalachian Basin.



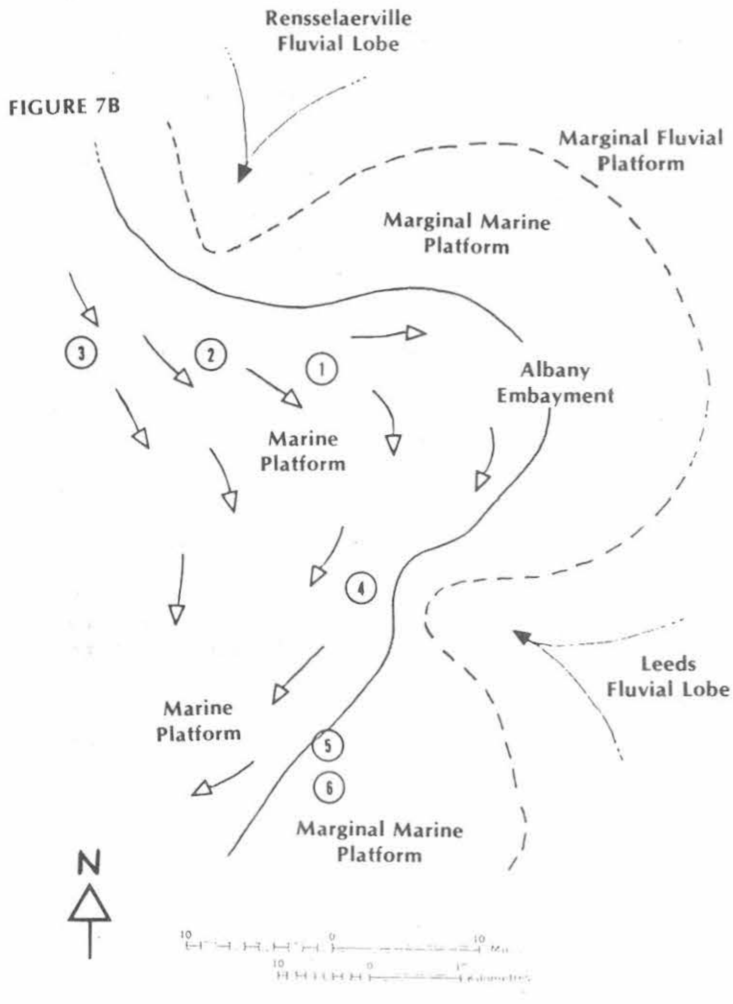


Figure 7. Paleogeography and depositional environments associated with the constructional (7A) and destructional (7B) phases of delta development.

A persistent subsiding basin existed in the present Westerlo - Albany area while fluvial and marginal deltaic distributaries with extensive sand flats continued to develop prograding deltaic lobes on each side of Albany Bay (Figure 7A). During the short transgression represented by the Mottville carbonates and clastics, the seas cleared, corals grew on the substrate of the delta slope, and shoals and bars developed on the shallow delta platform. The intervening muds had a rich fauna of bivalves and brachiopods. Vertical accretion was minimal as sediment was often redistributed into nearshore or offshore lateral transport systems. The strandline contained extensive tidal flats and broad channels along the embayments with reworked river mouth bars and sand shoals developing along the deltaic lobes. The interdistributary bays, originally filled with silt and mud now became the brackish coastal swamp that provided the habitat for the growth and development of extensive Eospermatoperis seed ferns (Figure 7B).

Within a relatively short time the pattern of reworking and lateral accretion again gave way to deltaic progradation. This change in pattern was almost unnoticed on the marine delta platform, but in the nearshore area the transgressive sands which had truncated the earlier marginal fluvial deposits were themselves nearly truncated and eroded by the following fluvial succession. This field trip road log, which follows, will examine the transgressive and restrictive nature of the Mottville clastic correlatives as they were developed on the marine and fluvial delta platform.

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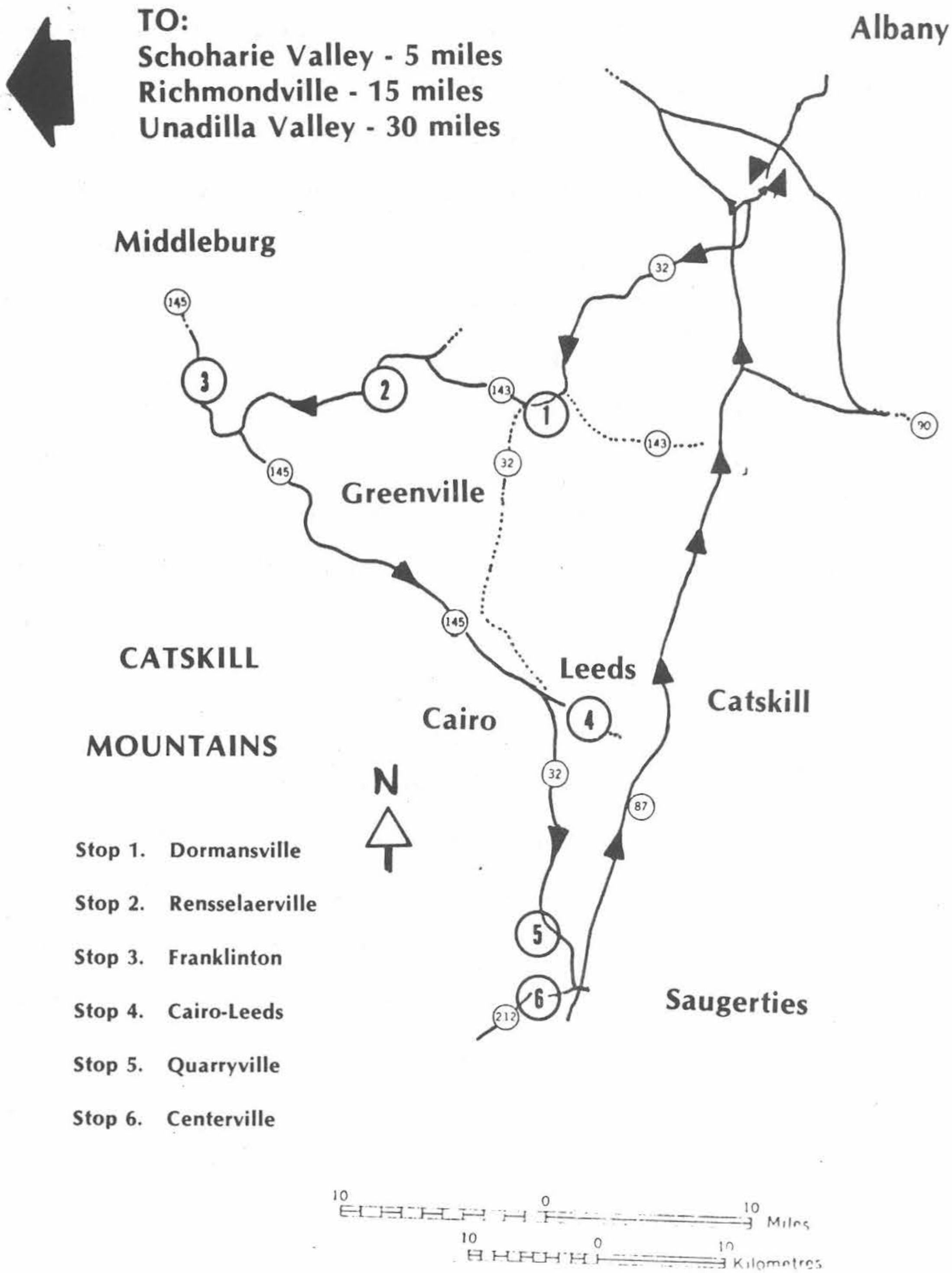
TO:
Schoharie Valley - 5 miles
Richmondville - 15 miles
Unadilla Valley - 30 miles
Albany
Middleburg
145
3
2
143
1
32
143
90
145
Greenville
32
145
CATSKILL
MOUNTAINS
Leeds
Cairo
4
Catskill
32
87
N
Stop 1. Dormansville
Stop 2. Rensselaerville
Stop 3. Franklinton
Stop 4. Cairo-Leeds
Stop 5. Quarryville
Stop 6. Centerville
5
6
212
Saugerties
10
0
10
Miles
10
0
10
Kilometres

FIGURE 8

Road Log Troy - Field Trip Area - and Return

	Mileage	Cumulative Mileage
Leave Houson Field House on R.P.I. Campus	0.0	0.0
Follow signs to Rt. 7 west	1.2	1.2
Cross bridge and follow signs to I 787 South	1.0	2.2
Continue S. on Rt. 787 to junction with Rt. 32 Exit here	9.1	19.3
Junction of Rts. 32 with 9W and 144 - turn right on Rt. 32	1.3	12.6
Junction of Rt. 32 S. and 9W (turn left at light onto Rt. 32)	0.6	13.2
On Rt. 32 - Pass through Haucks Corners and Feura Bush	5.0	18.2
Just after outcrop of Otsego Shale - junction of Rts. 32 and 143 east bear right onto Rt.32S	5.2	23.4
Junction of Rts. 32 and 143 West - continue straight on Rt. 143	2.7	26.1
Climb hill on Rt. 143 and enter Dormansville - park in wide driveway near crest of hill at home of M. Rossner	0.5	26.6
Stop 1A - Dormansville		
Drive across Rt. 143 to dirt road opposite driveway (Lobdell Mills Rd.) and park at first quarry on left	0.2	26.8
Stop 1B Lobdell Mills Rd. Quarry		
Return to Rt. 143 and turn left (west) toward Westerlo	0.3	27.1
Junction of Rt. 143 and Albany Co. Rd. #1 in Westerlo - continue <u>straight</u> on County Rd.#1	3.6	30.7
Junction with Rt. 85 at stop sign (opposite Dutchman's Rest) - turn left onto Rt. 85	2.7	33.4
T-junction at Rensselaerville; turn right onto Rt. 85 and once across bridge, continue on	4.4	37.8
Albany Co. Rd. #353. Climb hill and park in Rensselaerville Primary School parking lot	0.3	38.1
Stop 2 Edmund Hyuck Preserve - Rensselaerville Falls		
Upon return - continue up hill and take right	0.2	38.3
fork toward Livingstonville. Enter Schoharie Co. on Albany Co. Rd. #353	4.4	42.7
Follow winding road to junction with Rt. 145 at Livingstonville - turn right onto Rt. 145	3.3	46.0
Continue W. on Rt. 145 to outcrop on right	3.8	49.8
Stop 3 Roadcut on Rt. 145 at Franklinton		
Turn around and return on Rt. 145 toward Livingstonville	5.4	55.2
Continue E. on Rt. 145 to Rt. 81 - stay on Rt.145	6.2	61.4
Continue E. on Rt. 145 to junction with Rt. 23 and turn left onto Rt. 23	12.6	74.0
Continue E. on Rt. 23 to junction with Rt. 32 - stay straight on Rt. 23. Alternate Stop 4	2.5	76.5
Continue E. on Rt. 23 to Cairo Junction Rd., turn right (S.) and park. Stop 4 - Catskill Creek near Leeds	3.7	80.2
Continue S. on Cairo Junction Rd. to junction with Rt. 32 and then S. on Rt. 32	2.4	82.6

	Mileage	Cumulative Mileage
Continue S. on Rt. 32 across intersections with Rt. 23A and 32A	5.1	87.7
Slow down at roadcut between Quarryville gas stations and stop on roadside	2.7	90.4
Continue 50 meters and turn left onto Ulster Co. Rd. #36	0.1	90.5
Stop 5A Quarry at town garage - Quarryville		
Return on Rd. #36 to Rt. 32 and turn right -stop at road cut below gas station	0.3	90.8
Stop 5B Roadcut on Rt. 32 near Quarryville		
Continue S. on Rt. 32 past Thruway - south entrance	2.7	93.5
Junction of Rt. 32 with Rt. 212; turn right onto Rt. 212	0.3	93.8
Pass through Veteran, turn right onto old Rt. 212 before sign to Custerville, and follow this "loop" back out to junction with Rt. 212	2.1	95.9
Stop 6 Roadcut - Rt. 212 at Centerville		
Turn left and follow Rt. 212 north to Thruway N. entrance at Saugerties	2.5	98.4
Follow Thruway N. to Albany Exit 23 and then Rt. 787 back to R.P.I. campus	52.2	150.6

DESCRIPTION OF FIELD TRIP STOPS

Stop 1 - Rt. 143 west of Dormansville

Units - Solsville Member; facies - Chemung; depositional environment - nearshore marine delta platform in marginal embayment (Albany Bay)

Stop 1A - Quarry on N. side of road near home of Mr. M. Rossner

Description: While a few 0.2-0.5 meter planar crossbedded sandstones appear somewhat lower in the section, this is the first major lenticular sandstone in the area. The 2-meter sandstone has crossbeds, thin laminations, and local truncation surfaces. It contains a few bivalves (Cypricardella) lateral bioturbation structures, mud clasts, and plant fragments. The planar crossbedding trends N. 70° W - S 60° E, suggesting an onshore-offshore current influence. The sandstones are interpreted as prograding river mouth bars. The section is unique because strata at this interval are redbeds in the adjacent quadrangles - the marine Marcellus being nearly 60 meters thicker than sections to the west and south. The area has been termed "Albany Bay" by Goldring (1943) - see Figure 7.

Stop 1B. Quarry on Lobdell Mills Road across Rt. 143. Quarry consists of 2 meters of medium-dark gray siltstone and shale with several Mucrospirifer coquinite horizons. Associated fossils include a diverse assemblege consisting of: Camarotoechia, Athyris, Chonetes, and the bivalves Modiomorpha, Paracyclas, and Grammysia. Flatbedded, fine-grained sandstones with coquinites are common in the Dormansville-Westerlo area at an elevation of 1200-1300 feet, suggesting brief periods of strong agitation in relatively shallow water. The abundance of sessile epifaunal filter feeders suggests an abundance of suspended organic matter in deep quiet water. These contrary interpretations may be resolved by considering the embayed marine platform to also contain localized sandy shoals and broad muddy lagoons. A 0.8 meter crossbedded calcareous sandstone occurs on the N. side of Rt. 143 0.3 miles west of here (8 meters higher in the section) and this is believed to represent the clastic correlative to the Mottville in this region (Wolff, 1969).

Stop 2. Rensselaerville Falls. Edmund N. Huycks Preserve (Walking tour - cameras only; no hammers please)

Units - Solsville, Mottville correlatives, Panther Mt., Plattekill; facies - Chemung and Catskill; depositional environment - marine delta platform, brackish lagoonal (interdistributary), and floodplain - alluvial channel.

Description: The 22 meter section below the roadway bridge consists of flat, thick-bedded to massive sandstones or low-angle planar crossbedded sandstones interbedded with dark gray silty mudstones and shale - lithologically and stratigraphically similar to the Solsville Sandstone section at Stop 1, but without the coquinites. In the park, the section below the falls consists of 1-2 meters of medium-grained sandstones with some sinuous ripples (crests trend N 50° W). These may represent the top of the Solsville, though the presence of Pterinopectin macrodonta suggested the lowest Skaneateles (Mottville?) to Goldring (1943 p. 266 and 268).

The lower falls contain megarippled sandstones capped by a light-gray, bar-like, 1-1.2 meter crossbedded sandstone with cross sets trending S 70° W (3°) and N 70°E (15°). These are unique - the only such sandstones with such an internal and external geometry within either stratigraphic formation - see Figure 8A. They are interpreted as reworked river mouth or nearshore sand deposits formed during the clearing of the seas that produced the Mottville Limestone.

In ascending the falls, note that the bars are overlain by 16 meters of fine-grained, flat-bedded thin sandstone and siltstone with thin seams of black shale. These are non-marine

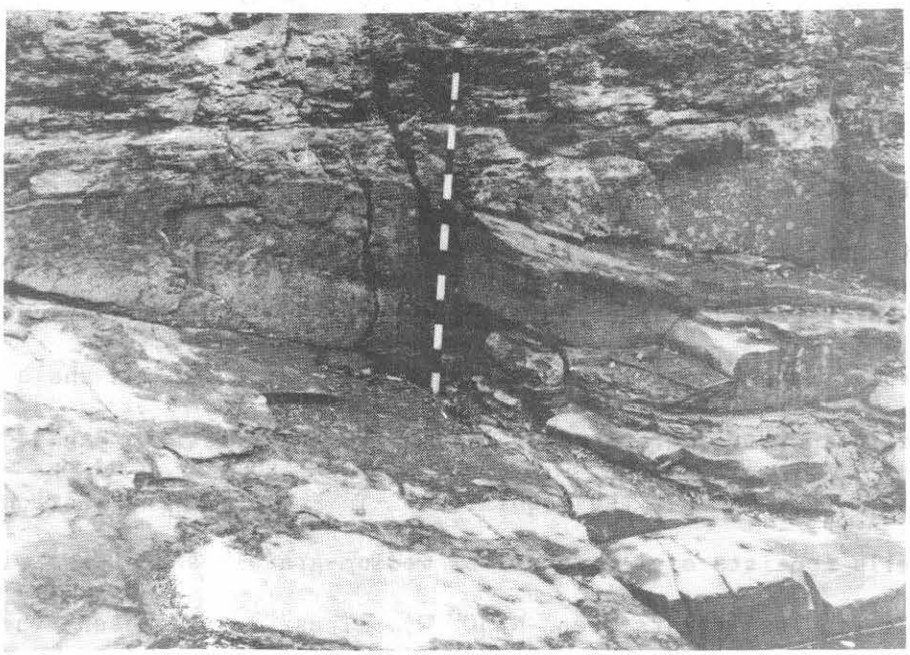

Figure 8A Inclined rippled surface of bar-like Mottville Clastic Correlatives at base of Rensselaerville Falls. (Stop 2) (Rod equals 14 decimeters or 1.4 meters) strata, formed by vertical accretion, with the black shales containing small ostracods (Beyrichia) and phyllopods (Estheria) that indicate a brackish water environment (Goldring, 1935, p.164). There is also a gradual color change from medium-gray to olive-gray to mottled olive green-maroon red to red as one ascends the section. The falls are capped by 2.3 meters of gray, medium-coarse grained sandstones that truncate the red mudstone. These trend S 75° W and contain basal clasts of white micrite and red-green mud.

The section is interpreted as one demonstrating the progressive change from open marine to marginal shoal-lagoon brackish water conditions. The persistence of fine-grained sandstone and shale suggest the continual infilling of a marginal embayment - perhaps the continuation of "Albany Bay". The erosional contact at the base of the channel sandstones, with the encroachment of a deltaic distributary from the northeast indicates the start of alluvial sedimentation on the delta platform.

Climb to the top of the falls, cross over the footbridge, climb a short hill, and then return on the trail that descends on the opposite side of the ravine.

Stop 3. Rt. 143 at Franklinton

Units: Mottville clastic correlatives; facies - Chemung; depositional environment - shoal on nearshore marine delta platform.

Description: This 6-meter section exhibits the interfingering of two en-echelon "bar-like" sandstones that are overlain by 1 meter of fossiliferous dark gray shales. The medium-grained sandstones are light-gray in color (weathers a dark brown) and calcareous with individual planar crossbeds 2-4 cm. thick and trending N 50-70° E at slopes of 4-7° (similar to the section at Stop 2 - see Figure 9 on page 22).

The unit coarsens upward and grades into the overlying marine shales which contain Glyptodesma, Mucrospirifer and Camarotoechia. The entire section is 0.2 miles long and is interpreted as a reworking of marine delta platform deposits into these transgressive sand bars on the outer fringes of the prograding deltaic lobe visited at Stop 2 (see also Figs. 2, 4 and 7).

Alternate Stop 4. Rt. 145 S. of Cairo after the junction with Rt.32.

Unit: Plattekill of the Catskill Facies on the alluvial delta platform.

Description: This 12-meter section represents two upward-fining fluvial cycles well within the Plattekill Formation and illustrates the major difference between the progradational marine sandstone lenses of the platform (Stops 1 and 2), reworked transgressive coastal marine sandstone bars (Stop 3) and the fluvial sandstone channels.

The sands are dark gray, medium-coarse thick bedded (10-30 cm.) and planar-crossbedded depositional units with infrequent scour and fill pockets across a sharply truncated megarippled surface. Plant fragments and olive-red mud clasts are common.

The gradational nature of the massive, irregularly bedded sandstones into gray-red silty mudstone indicate, through channel abandonment, the gradual change from channel to levee to floodplain environment. This rhythmic pattern is prevalent through the next 400 meters of section in the nearby Catskill Mts. The dominance of gray channel sandstone over red floodplain siltstone-mudstone at this interval suggest rapid seaward delta progradation of many distributaries, with relatively little vertical accretion in floodplain and interdistributary bay environments. Gradients were probably low, but the large scale megaripples and scour suggest high current velocities and perhaps gently curved rather than true meandering rivers. In places, channel deposits directly overlay earlier deposits of similar origin, indicating complete lateral and vertical erosion of the overbank red mudstones and a nested sequence of irregular, sub-parallel distributary channels prograding into the basin.

Stop 4 - On Catskill Creek off Rt. 145 and Rt. 23B near Leeds
Units: Mottville and Plattekill Members; facies - Chemung and Catskill; depositional environment - marginal fluvial and fluvial.

This section is stratigraphically similar to the one at Stop 2 (Rensselaerville Falls) but begins within a 4-meter upward-fining sequence of planar crossbedded channel sandstones overlain by olive gray and dull maroon mudstones and shales as overbank and floodplain deposits. This first fluvial cycle also has the first "redbeds" of the Plattekill Formation. North and south of this area the first fluvial deposits are not red, and the thickness of this non-red alluvial sequence increases to locally form the Ashokan Member. Nearly all of the important flagstone quarries in this region came from the Ashokan. The unit consists of flat-bedded and low angle planar and trough crossbedded sandstones with sharp basal contacts and an abundance of mud clasts and plant fragments. The associated olive and gray shales rarely contain marine fossils.

The Ashokan Member is distinguished from the Plattekill by the lack of redbeds, the dominance of medium-sized (2-4 cm.) flat-bedded sandstones (as flagstone) and the dominance of thinly laminated flat-bedded sandstone. These criteria along with current lineation, bioturbation, mottling, load casts, and lateral sediment associations suggest the development of extensive sand flats and marginal channels between the major deltaic lobes (Figures 3 and 7).

Above the initial fluvial sequence are red-green mottled sandstones and some thin seams of black shale with ostracods (Beyrichia). The overlying 3 meter section consists of gray-green flagstone, massive, calcareous sandstone with mud clasts, and interbedded slumped and bioturbated sandstone with an erosional top. This represents a short "upward coarsening" sequence, with some period for reworking and burrowing by organisms before erosion, and is taken to represent a tidal or supertidal sandflat and also the clastic correlatives to the Mottville interval in this area. Above this truncation the next 6 meters consist primarily of light-gray-olive green siltstone mudstone and shale, with abundant plant fragments and believed to represent overbank disposition as marsh deposits above the sandflats. These mudstones are truncated by a 1.6 meter section of planar crossbedded gray sandstones with megaripples, scour and fill pockets, load casts, and some bioturbation - the return to fluvial conditions. It is overlain by the typical sequence of gray to olive-green to maroon-red mudstones and shales - the second fluvial cycle.

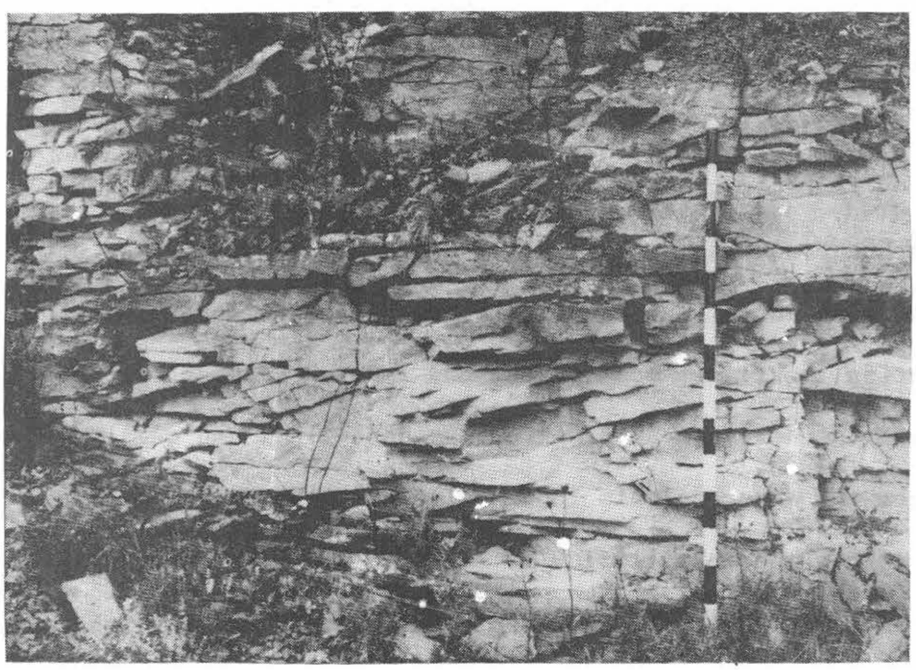

Figure 9. Planar crossbedded light gray calcareous sandstones of en-echelon "bar-like" Mottville Clastic Correlatives on Rt. 145 at Franklinton (Stop 3).

The correlation of the light gray calcareous crossbedded sandstones as "Mottville correlatives" is based partly on the unique lithology within the fluvial section but moreso on the position of this unit between the first two fluvial cycles, as will be re-examined at Stops 5 and 6 when we again view this interval within an embayment.

Stop 5 - off Rt. 32 near Quarryville

Units - Upper Mt. Marion (Solsville), Mottville correlatives, and Ashokan; facies - Chemung; depositional environment - nearshore marine, marginal channel and sandflats.

Stop 5A - Along Rt. 32 before junction with County Rd. #36, and at quarry near town garage on Rd. #36.

Description: The top of the section (on Rt. 32) contains extensive flat-bedded and low angle planar crossbedded and laminated gray sandstones (Unit C) - the type used for the flagstone industry that has dominated this region for the past 75 years. These truncate a 1.2 meter section of massive calcareous sandstones and olive mudstone (the Mottville clastic correlatives - Unit B) that are underlain by a 1.8 meter interval of megarippled and planar crossbedded and laminated sandstones with mud clasts and scour and fill pockets, and massive flat-bedded sandstones - Unit A. Here too the clastic correlatives form marginal sandflat or marsh environments between two marginal or fluvial channels (as at Stop 4).

The quarry on County Rd. #36 consists of 2 meters of thin-bedded planar crossbedded gray sandstone (Unit A) overlain by an 0.5-0.8 meter undulatory surface with scour and fill structures, in turn overlain by a 1.3 meter light gray calcareous, crossbedded sandstone (Unit B).

The laminated flat-bedded and cross-bedded sandstones are interpreted as tidal sand flats and beaches fronting the deltaic marshes. The megarippled surface and scour and fill with pockets of olive mudstone add support to this, the upward fining sequence suggesting the filling in of a shallow embayment behind the tidal sand flats. The overlying laminated and slightly sorted "bar-like" sandstone represents the reworking of the sandflats into a shoal or beach (Unit B). The truncation of this sequence by the next series of gray crossbedded sandstones with basal mud clasts and plant debris suggests the presence of a marginal channel or river mouth bar. The large tree molds (Wolff, 1969) indicate a close proximity to the seed fern forests that inhabited the local coastal swamp.

Stop 5B - On Rt. 32 below junction with County Rd. #36.

This 24-meter outcrop consists of massive marine sandstones and dark gray shales with several horizons of ball and pillow structures (Figure 10). It is known locally as the Mt. Marion Formation and is correlative with the Solsville Member of the

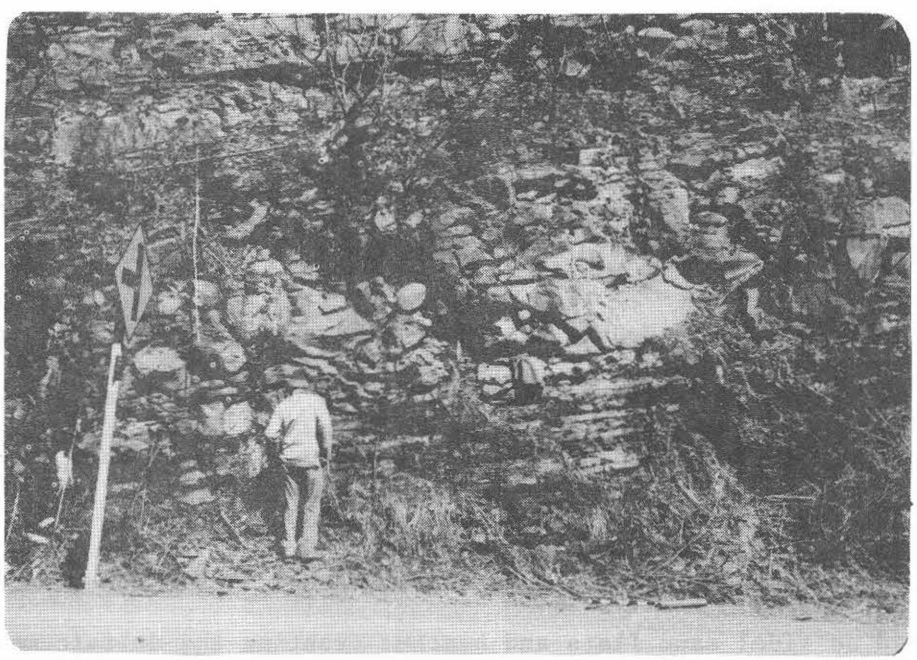

Figure 10. Massive sandstones and interbedded shales of the marine delta platform with "ball and pillow" structures. (Stop 5B)

Marcellus Formation. Other characteristic features include long, low angle planar forests, coquinite horizons and the thin but persistent 7 cm. Alcove Conglomerate that can be traced to Stop 1 at Dormansville.

The section (as at Stop 1) represents the marine delta platform with the ball and pillow structures interpreted as load casts developed from sediment foundering during earthquake activity. The seismic tremors could also create tsunami which extend into the embayments and channels and transport the marginal and fluvial deposits (and the pebble bed) onto the marine platform (Wolff, 1977). A possible Middle Devonian astrobleme may be buried within the Catskill Mountains only 9 kilometers from this outcrop (Isachsen, Y.W. et.al. 1977) suggesting an even more extreme origin for these deposits.

Stop 6. Rt. 212 near Centerville

Units - Mottville Correlatives and Ashokan Member; facies - Chemung; depositional environment - marginal marine and fluvial.

Description - Here the suggested Mottville correlatives are sandwiched between the first two marginal channels or river mouth bars (See Figure 11). The lower 2.2 meter section consists of medium-grained planar crossbedded gray sandstones with basal mud clasts directly overlying marine strata. The unit is overlain by 0.3 meters of dark shale and 1 meter of massive light gray sandstone.

The next 4.5 meters comprise the Mottville correlatives and consist of 2 meters of alternating massive gray calcareous sandstones and dark shales with bioturbation markings and load casts. These are truncated by 2 meters of thinly laminated and crossbedded sandstone, 1.3 meters of massive light gray calcareous sandstone, and 1.2 meters of interbedded fine-grained sandstone and dark shale with flaser bedding. The sequence ends with 1 meter of rippled sandstone and shale with extensive lateral worm burrows. (Figure 12)

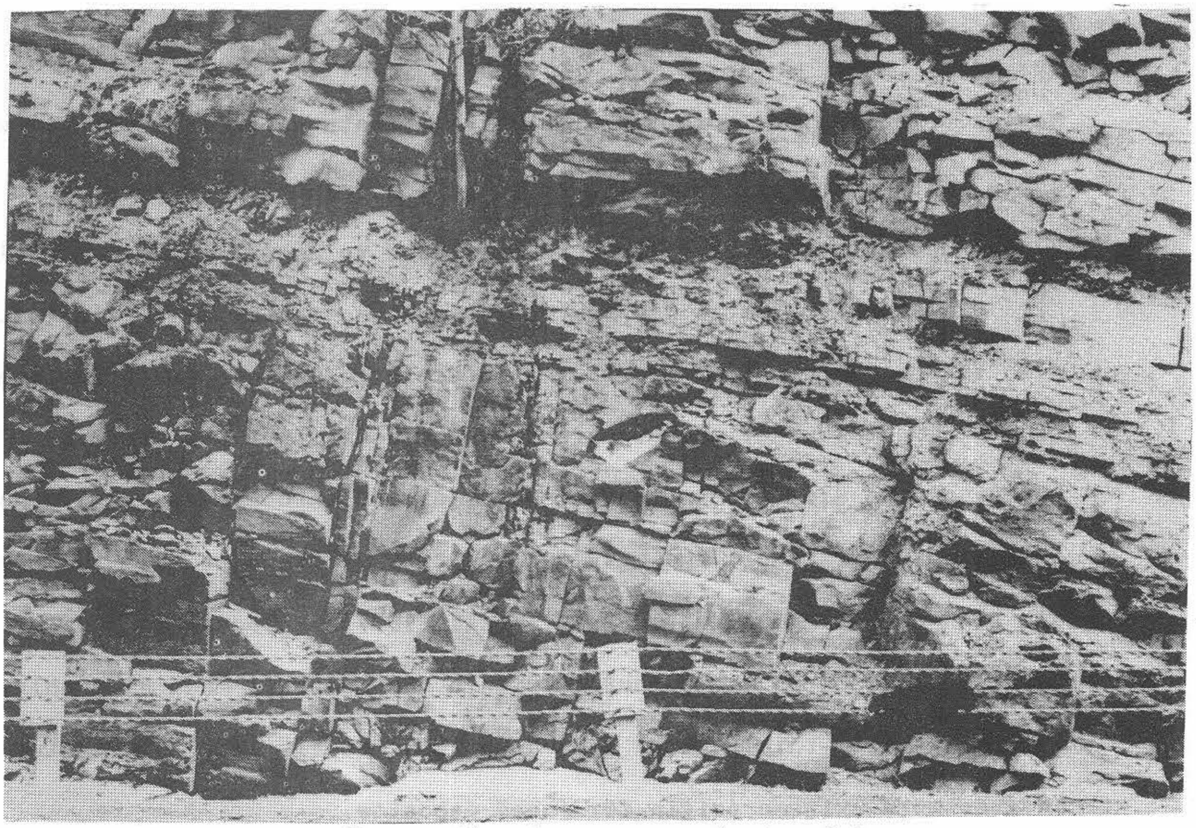

Figure 11. Wedge of "Mottville Clastic Correlatives" between the first two major fluvial sequences of the Ashokan Member. (Stop 6.)

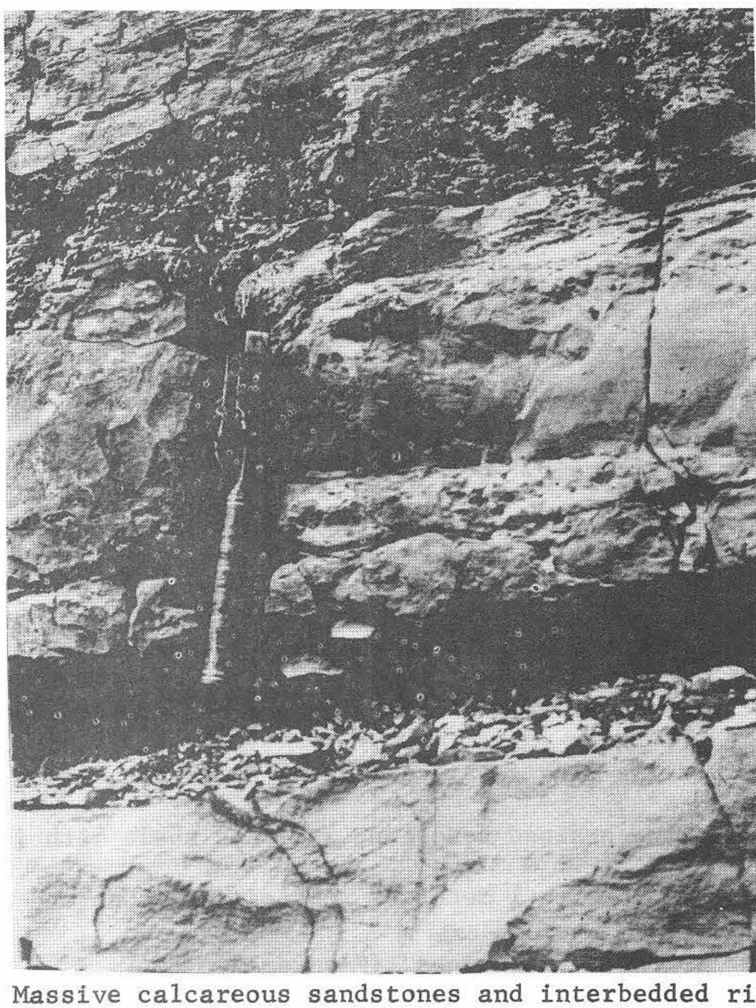

Figure 12. Massive calcareous sandstones and interbedded rippled and bioturbated shales - the reworked intertidal deposits of the Mottville Clastic Correlatives.

The outcrop is capped by an 8 meter sequence of thick beds of gray planar crossbedded sandstone with megarippled surfaces and abundant mud clasts.

The lower sequence shows small scale polymodal trough cross bedding and lamination suggesting the periodic reworking of a marginal channel or river mouth bar. The middle section with the massive, crossbedded and cross laminated calcareous sandstones, ripples, flaser bedding and bioturbation suggests the preservation of intertidal sand flats, and shallow lagoons. The massive crossbedded and burrowed light gray calcareous sands may indicate the pressure of a beach or reworked sand flat environment. This short interval of marine resedimentation is sharply truncated by the overlying fluvial progradation that nearly erodes this transgressive sequence. However, the persistence of these unique reworked deposits both to the north and to the south of this region (Wolff, 1969) and to the west (Grasso and Wolff, 1977) indicates that the extension of the Mottville clastic correlative is possible through these unique lateral sedimentary associations.

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