CAMBRO-ORDOVICIAN SHOALING AND TIDAL DEPOSITS MARGINAL TO IAPETUS OCEAN AND MIDDLE TO UPPER DEVONIAN PERITIDAL DEPOSITS OF THE CATSKILL FAN-DELTAIC COMPLEX

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This field trip, in which sedimentary facies deposited in Cambrian, Ordovician, and Middle to Upper Devonian shallow-water marine environments will be examined, has been divided into two parts. The first three stops will be devoted to facies of the Cambro-Ordovician period, and the last three will cover the Middle to Upper Devonian facies.

Cambro-Ordovician Shoaling and Tidal Deposits

The area around the Rensselaer Center of Applied Geology in Troy, N.Y. is known for its diversity of sedimentary geology due to its unique location. From Early Cambrian through Early Ordovician, the Center would have been on a carbonate shelf of the Proto-Atlantic (Iapetus) Ocean. During this time, much of the North American continent was a shallow epeiric shelf sea, analogous to the present-day Bahama Bank. On the eastern edge of this sea, i.e. on the eastern edge of this continent, carbonate sediment moved down a relatively steep slope by slides, slumps, turbidity currents, mud flows, and sandfalls, and came to rest at the deep-water basin margin (rise) depositing a shale facies (Figure 1) (Sanders and Friedman, 1967, p. 240-248; Friedman, 1972, p. 3; Friedman, 1979, Friedman et al, 1982, Keith and Friedman, 1977, 1978; Friedman and Sanders, 1978, p. 389, 392). Shale also formed much of the basinal facies at greater oceanic depths.

The Cambro-Ordovician shelf to basin transition facies, which would have originally been located east of Rutland, Vermont, has been tectonically displaced across the shelf facies. Today, the exposures on and near the Rensselaer Center of Applied Geology are Cambrian and Early Ordovician rocks of basin margin (rise) and deep basin facies (shales deposited in the Middle Ordovician (Schenectady) west of the Rensselaer Center of Applied Geology are autochthonous basin facies).

To the west, Cambrian and Ordovician carbonate shelf facies are exposed that are analagous to those of the west shore of Andros Island on the Great Bahama Bank, (Friedman, 1972) (Figure 1). This area was probably an active hinge line between the continent to the west and the ocean to the east, similar to the Jurassic hinge line of the eastern Mediterranean between carbonate shelf facies and deep-water shoals (Friedman, Barzel and Derin, 1971). Early in geosynclinal history, such hinge lines in mountain belts are fixed by contemporaneous down-to-basin normal faulting (Rodgers,

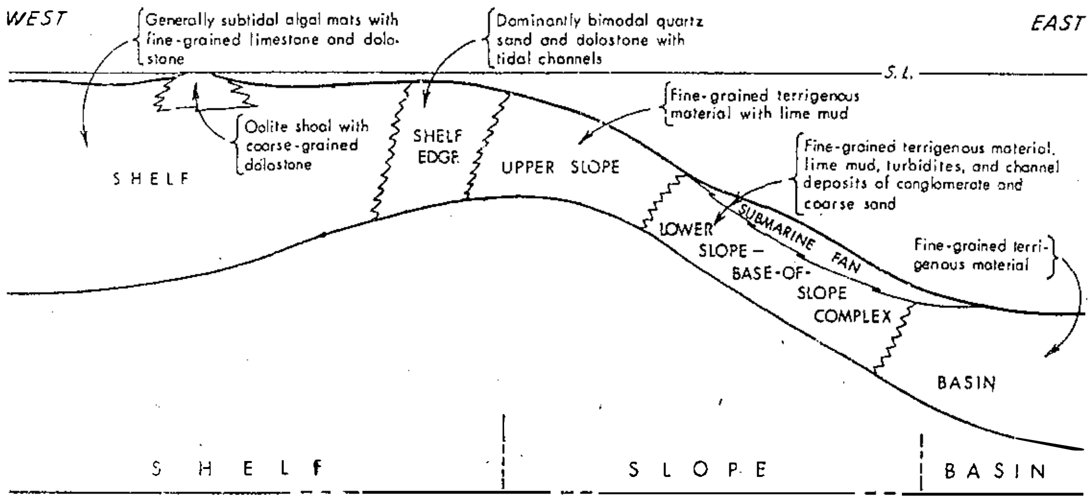


Figure 1. Diagrammatic sketch map showing depositional environments and characteristic sediments of Proto-Atlantic (Iapetus) Ocean for eastern New York and western Vermont during the Early Paleozoic (Keith and Friedman, 1977, Fig. 2, p. 1222, Friedman et al., 1979 (IAS Guidebook), Fig. 1, p. 48).

1968, quoting Truempy, 1960), as probably occurred with the rocks of the area near the Rensselaer Center of Applied Geology. Later thrusting lifted the deep-water facies across the shelf facies along hinge-line faults and resulted in the contiguity of the two facies. This later displacement was so great that the Cambrian and Early Ordovician deep-water sediments were shifted far west of their basin margin.

This occurrence of deep-water basin margin (rise) and basinal facies in the vicinity of the Rensselaer Center and carbonate shelf to the west are partly responsible for the great diversity in sedimentary facies in this area.

During the Cambrian and Ordovician periods shallow-water limestones and dolostones accumulated at the then-eastern edge of this submerged continent. On this field trip we shall study those which are part of the Tribes Hill Formation of lowermost Ordovician age (Fisher, 1954). The steep paleoslope, which marked the transition from the submerged continent to the deep sea, lay about 35 miles east of the present Tribes Hill exposures which we shall visit.

The carbonate rocks of the Tribes Hill Formation show many features such as mud cracks, birdseye textures, undulating stromatolitic structures, mottles, lumpy structures, scour-and-fill structures, flat pebbles, cross-beds, and, as a lithology, syngenetic dolostone (Friedman and Sanders, 1967; Friedman and Braun, 1975). The presence of these features suggests that the rocks were subjected to repeated shoaling and intermittent subaerial exposure. Most known Lower Ordovician shallow-water carbonates that underlie much of North America have features identical to these. The site of accumulation of the Tribes Hill carbonates however, is markedly different from that of most other Paleozoic carbonates that stretch across North America. Since the Tribes Hill carbonates were deposited close to the edge of the continent, diurnal or semi-diurnal fluctuations of the waters of the deep ocean should have left their mark on the Tribes Hill deposits, classifying them as tidal.

The most obvious of the morphologic features in modern tidal sediments are tidal channels. What may be ancient tidal channels can be observed in the rocks of the Tribes Hill Formation. Such channels have not been reported from the Cambro-Ordovician carbonate-rock sequences in other parts of North America.

The sizes of the channels in the Tribes Hill Formation are comparable to the sizes of modern tidal channels. Sharp basal truncations are typical. The material within the channel consists mostly of carbonate skeletal and intraclastic sand (biosparite and intrasparite), a high-energy facies. These channels cut into a mottled dolomitic micrite and biomicrite, a low-energy facies. Lodged within the channel fill are large blocks of micrite, up to 1 meter in diameter. They are thought to have been derived by undercutting of the banks. To accomplish such undercutting the currents in these channels must have flowed fast. The contrast between the high-energy facies filling the channels and the low-energy facies in the flats adjacent to the channels also suggests that currents in the channels flowed swiftly.

In Paleozoic limestones the products of shoal waters are ubiquitous, but tidal deposits may have been restricted to the margins of the continents where the epeiric shelf faced the deep ocean. The carbonate rocks of the Tribes Hill Formation may be an example of such a tidal sequence.

An essential constituent of the carbonate rocks of the Tribes Hill Formation is authigenic feldspar. Such feldspars are the end products of the zeolite alteration. In rocks older than mid-Paleozoic, any original zeolites probably have changed to feldspars, therefore zeolites are not found in sedimentary rocks as old as Early Ordovician. In volcaniclastic rocks of Cenozoic age, authigenic feldspar is known to be the end product of volcanic glass whose initial alteration product was a zeolite (Sheppard and Gude, 1969; Goodwin, 1973). The high concentration of feldspars caused stromatolitic laminae to weather in positive relief.

The feldspars in the Tribes Hill Formation are interpreted as wind-transported tephra that accumulated at the margin of the Proto-Atlantic (Iapetus) Ocean. The active volcanoes responsible for such tephra may have been parts of ancient island arcs (Braun and Friedman, 1969; Buyce and Friedman, 1975; Friedman and Sanders, 1978).

Middle To Upper Devonian Peritidal Deposits

The Devonian strata of New York State include one of the most complete fossiliferous records of Devonian time almost anywhere in the world. The carbonate strata in the Catskill Mountains are essentially flat-lying. They range from 2.4 to 2.5 km in thickness and decrease to about 1 km thick in the most western part of New York State. Among the Lower Devonian carbonates are the Helderberg Limestones, named after prominent cliffs along the northern and eastern margins of the Helderberg Mountains, a range of hills southwest of Troy and Albany. Carbonate strata of the

Middle Devonian include the Onondaga Limestone which forms a prominent westward escarpment across the State.

Parts of the Middle and Upper Devonian strata in New York State are sometimes referred to as the "Catskill redbeds." Included are various nonmarine, chiefly fluvial conglomerates and coarse sandstones, which were deposited as fans and by braided streams, and sandstones and red and green siltstones, which probably were deposited on flood plains of meandering rivers. These fluvial deposits are part of a vast wedge of sediment that was spread out along the southeast margins of the Appalachian seaway and eventually became so abundant that the shoreline was prograded several hundred kilometers to the west. A wide alluvial plain came to occupy part of the former seaway.

Beginning with the classic work of Joseph Barrell (1912, 1913, 1914) early in the twentieth century, it has been recognized that the thick complex of nonmarine "Catskill redbeds" overlying and interfingering with marine shales and sandstones was the work of ancient deltas. Modern sedimentologic studies have shown that the Devonian of the Catskill area includes sediments that were deposited in point-bar sequences and associated overbank deposits of flood-plain rivers, on fans, in braided streams, on intertidal flats, in lagoons, on barrier beaches, in various parts of marine deltas, and in shallow seas away from shore (Friedman and Sanders, 1978).

Although previous work has outlined and supported the concept that deltas were present in the Catskill region during the Devonian Period, (Barrell, 1914, 1923; Friedman, 1972; Friedman and Johnson, 1966; Humphreys and Friedman, 1975; Johnson and Friedman, 1969; Mazzullo, 1973; McCave, 1969a, 1969b, 1973; Rickard, 1975; Wolff, 1967a, 1967b), the actual strata that were deposited on marine deltas themselves have scarcely been mentioned. The chief emphasis has been placed instead on the marine strata upon which the marine deltas must have prograded; and on the nonmarine alluvial deposits of flood-plain rivers, braided streams, and fans, which aggraded upward above the topsets as supratopset strata. The marine strata, important because they contain fossils and are laterally persistent, are the basis for making stratigraphic subdivisions and correlations. The supratopset nonmarine strata have been studied because they are so well-exposed.

It is inferred that on the Devonian marine deltas of the Catskill region were deposited the clay shales, silt shales, and interbedded silt shales and fine-grained sandstones which intervene between the marine limestones or dark-colored marine shales below, and the thick nonmarine strata above. If this concept is correct, then from the generalized restored stratigraphic section it can be inferred that at least 4 episodes of westward progradation by marine deltas must have taken place. It can be concluded that the marine deltas were numerous, and that they prograded seaward very rapidly with respect to the rate of subsidence because the thickness of the inferred marine-deltaic strata is such a small porportion of the total Middle and Upper Devonian succession. Most of the subsidence took place after alluvial plains had become established on the topset parts of the marine deltas. Since the entire succession contains such thick supratopset strata, it is further surmised that the marine deltas must have built

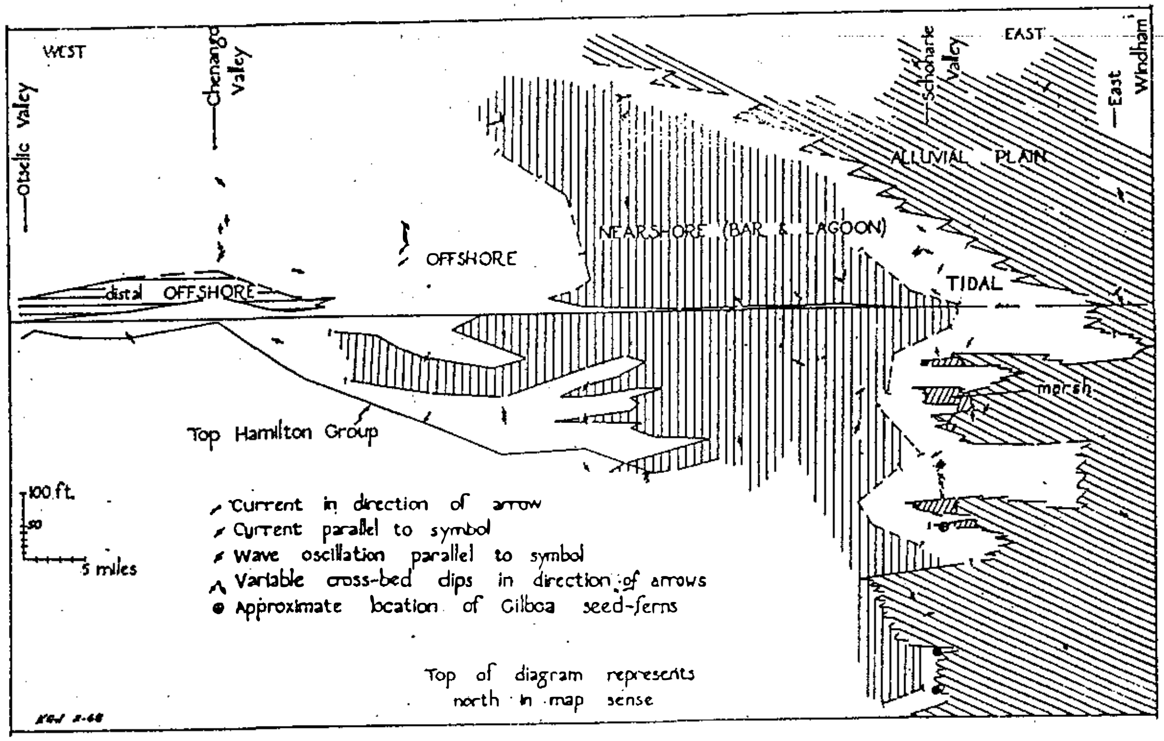


Figure 2. Depositional environments and current indicators, Tully Limestone and associated rocks, east-central New York State (Johnson and Friedman, 1969, p. 480).

westward to the point where the water deepened. The rates of westward growth of the marine delta lobes were checked while the supratopset strata thickened so conspicuously (Friedman and Sanders, 1978).

The absence of bar-finger sand prisms and pods further indicates that the Devonian marine deltas of the Catskill region were of the shoal-water variety. If any such sands are present, they should be located at the western edge of the former shallow platform, an area now covered by younger strata.

If the above conclusions are correct, then the thick, well-exposed supratopset beds of the Devonian marine-delta deposits should be separated from the true deltaic strata. Although both were products of progradation and subsidence, the deltas formed first, and afterwards, as subsidence continued, fans aggraded. To emphasize the inferred presence of both the marine deltas and the supratopset fans it has been suggested that the term "tectonic delta complex" (Friedman and Johnson, 1966) be abandoned and in its place the term "tectonic fan-delta complex" be substituted (Friedman and Sanders, 1978).

Part of the Catskill deltaic complex is represented in the stratigraphic record by the Tully Limestone. The name Tully Limestone applies to a series of beds which are well-exposed in central New York near the town of Tully (Vanuxem, 1838). In an eastward direction the limestone grades into very fine-grained clastic strata. Recognizable in the Tully interval are rocks indicative of various sedimentary environments including alluvial strata of channel and overbank origin, nearshore (bar and lagoon) facies, offshore facies, and sediments of tidal origin (Fig. 2).

Tidal sediments accumulated along the margins of protected coastal water bodies such as lagoons, estuaries, and bays. These sediments may be subdivided into tidal flats and tidal channels. In modern tidal environments, vertical sedimentary processes deposit silt and mud-grade size material on tidal flats. Cutting across these tidal flats is somewhat coarser sediment deposited by lateral sedimentary processes in tidal channels.

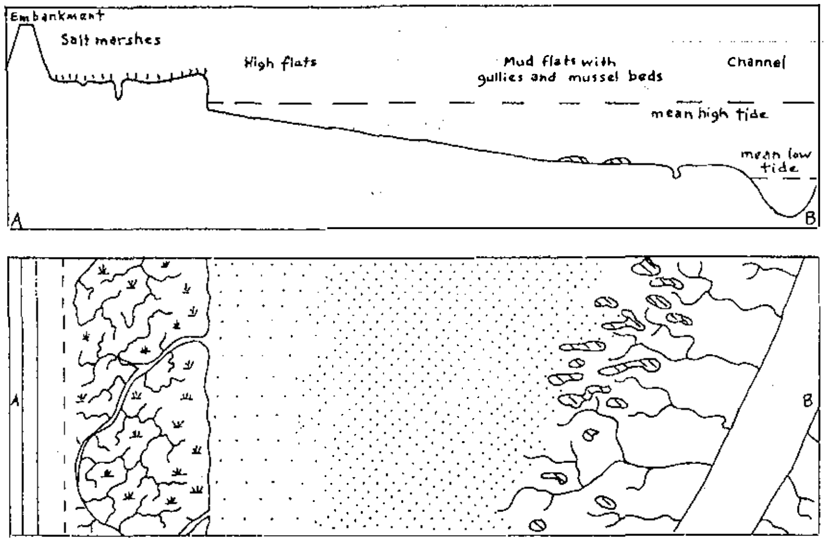
In the Catskill deltaic complex the tidal-flat sedimentation was of the Wadden-type, named after the intertidal sediments of the Wadden Sea, a part of the Rhine-Ems-Scheldt delta complex of northwestern Europe. Van Straaten (1950, 1954) subdivided the Wadden Sea tidal flats into (1) a lower seaward part, where tidal channels cut across and into mud and muddy-sand deposits, and (2) a higher landward part composed dominantly of sand.

In the lower tidal flats sedimentation proceeds at a relatively fast rate and there is little bioturbation, therefore fine cross-lamination and flaser bedding are preserved. Also characteristic of the lower tidal flats are well-developed incised tidal channels. These channels as well as the flaser bedding are lacking in the high tidal flats due to a lower rate of sedimentation and destruction of sedimentary features by organisms.

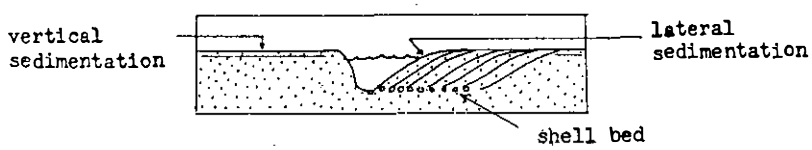
In modern tidal channels, a combination of eroded meander banks and deposition of sediment in slack water along the inner banks of meanders produces cross-bedded channel deposits both laterally and vertically. As flow slackens, fine sediment is deposited as parallel laminae. These sedimentary structures are also found in meandering alluvial channels. Two diagnostic characteristics of tidal channel sand facies however are (1) a close association with stata of marine origin and (2) the unique character of the basal channel lag concentrate. The basal lag concentrates of the Tully interval tidal channel facies consist of a polymictic pebble assemblage and abundant large spiriferid brachiopods of subtidal derivation. Often the calcium carbonate shell material is abundant enough to constitute a coquinite lithology (Johnson and Friedman, 1969). This type of allochthonous organic sedimentary accumulation has been noted in modern tidal flats and channels of the Wadden Sea, Easter Scheldt (Netherlands), and Bay of Arcachon (France) where the shells are typical open sea species that are washed into the tidal flat areas by flood tides (Van Straaten, 1956).

At the base of the clastics lies the Hamilton Group which is a 2500' interval of fossiliferous sandstone and shale thinning toward the west and southwest. The Gilboa Forest of Goldring (1924, 1927) can be found in the uppermost part of the Hamilton Group. Within the Gilboa Formation are fossils of giant seed ferns which grew in a swamp that was located near the strandline of the Catskill deltaic complex toward the end of the Middle Devonian.

The peritidal clastic correlatives of the Tully Limestone evolved during a transgressive phase within the general progradational framework of the Catskill deltaic complex. The growth of a submarine topographic high, the Chenango Valley high (Heckel, 1966), about 60 miles offshore while deposi-



Wadden Sea Tidal Flat Environments



Vertical and Lateral Sedimentary Processes

Figure 3. Sedimentary environments of the Wadden Sea intertidal zone (after Van Straaten, 1954, p. 27; Johnson and Friedman, 1969, p. 472).

tion was occurring was a primary structural control. This structure formed a barrier to terrigenous material that was moving westward from the source area into the marine basin, making it possible for carbonate sediment to accumulate. The clastic material accumulated in a basin-margin trough or depression which subsided intermittently as deposition continued. During the transgressive phase landward migration of the strandline caused river mouth drowning and resulted in more widespread estuarine (tidal) conditions as the Tully interval was accumulating.

ITINERARY

Figure 4 is the road log.

Cambro-Ordovician Shoaling and Tidal Deposits

Depart from the parking lot of the Performing Arts Center and turn north on NY 50.

MILES FROM LAST POINT	CUMULATIVE MILEAGE	ROUTE DESCRIPTION
0.6	0.6	Bear left following sign to NY 29.

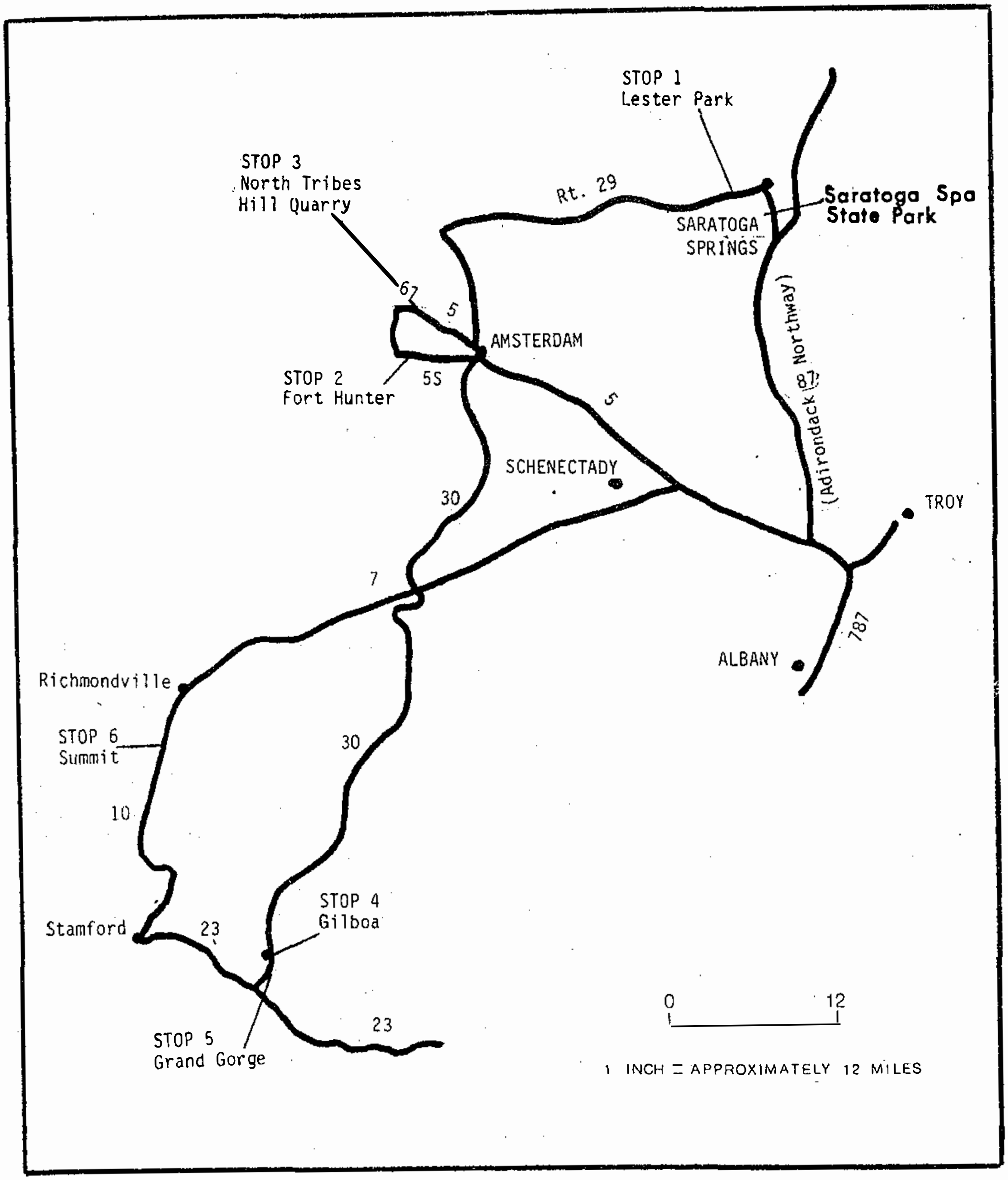


Figure 4. Road log for field trip.

1.2	1.8	Drive to traffic light and turn left (west) on NY 29.
2.1	3.9	Turn right (north) on Petrified Gardens Road; drive past "Petrified Gardens" to Lester Park.
1.2	5.1	Alight at Lester Park.

STOP 1. PRODUCTS OF INTERTIDAL ENVIRONMENT: DOMED ALGAL MATS (CABBAGE HEADS)

This locality is the site of one of the finest domed algal mats to be seen anywhere preserved in ancient rocks. On the east side of the road in Lester Park a glaciated surface exposes horizontal sections of the cabbage-shaped heads composed of vertically stacked, hemispherical stromatolites (Figure 5). These structures, known as Cryptozoons, have been classically described by James Hall (1847, 1883), Cushing and Ruedemann (1914), and Goldring (1938); an even earlier study drew attention to the presence of ooids as the first reported ooid occurrence in North America (Steele, 1825). Interest in these rocks has been revived as they are useful environmental indicators (Logan, 1961, Fisher, 1965; Halley, 1971). The algal heads are composed of discrete club-shaped or columnar structures built of hemispheroidal stromatolites expanding upward from a base, although continued expansion may result in the fusion of neighboring colonies into a Collenia-type structure (Logan, Rezak, Ginsburg, 1964). The stromatolites are part of the Hoyt Limestone of Late Cambrian (Trempealeauan) age. An intertidal origin has been inferred for these stromatolites (Fig. 6, 7 and 8).

Figure 5. Top view of algal stromatolites showing domed laminae known as cabbage-head structures, Hoyt Limestone (Upper Cambrian), Lester Park, New York (Stop 1).

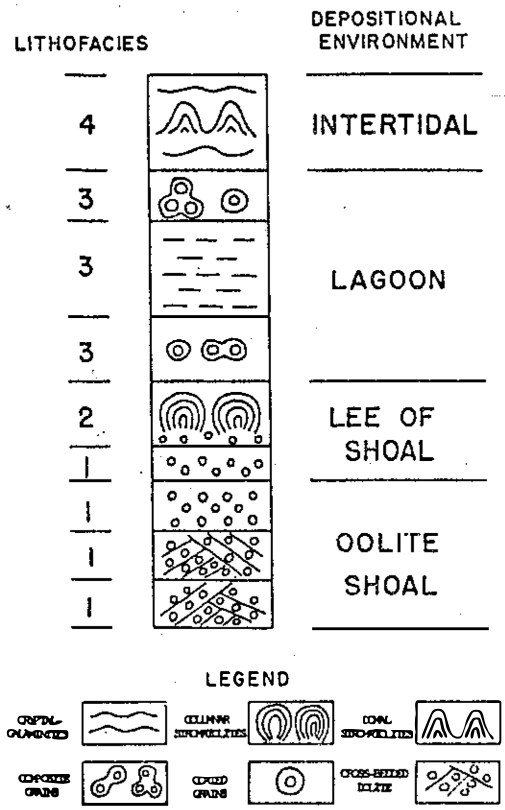


Figure 6. Vertical sequence, lower Lester Park section. The vertical sequence shown by this section reflects a vertically continuous progradational sequence. The upward increase in lithofacies number suggests progressivly shoreward deposition. (R. W. Owen and G. M. Friedman, 1984, Fig. 8, p. 230.)

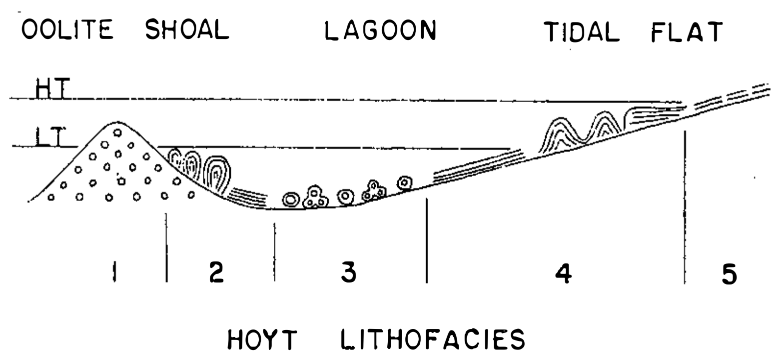


Figure 7. Hypothesized depositional model, cross-section view. Note the similarity in horizontal sequence of lithofacies and vertical sequence of lower Lester Park section (figure 8). Vertical scale greatly exaggerated. (R. W. Owen and G. M. Friedman, 1984, Fig. 13, p. 233.)

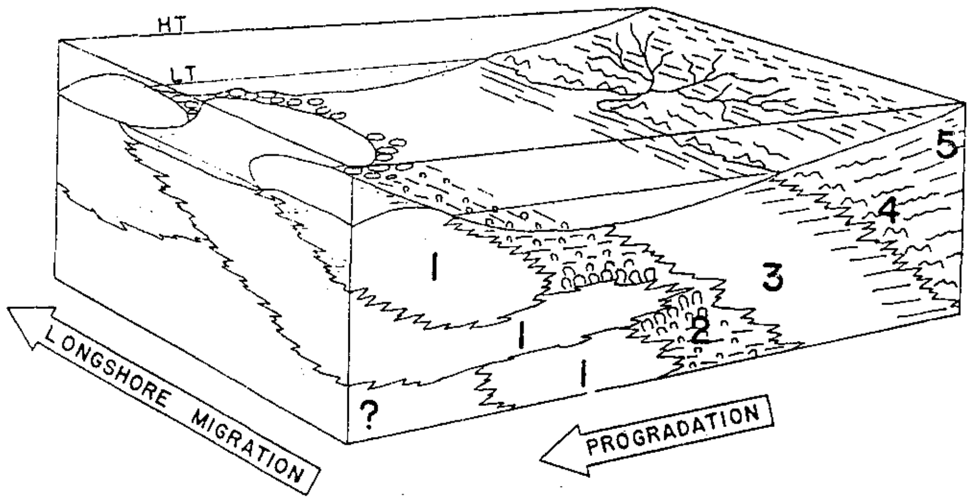


Figure 8. Facies relations resulting from longshore migration of oolite shoals and progradation of carbonate build-up. Block diagram shows generalized facies relations interpreted for dynamic Hoyt depositional mode. Note that high-relief columnar stromatolites and low-relief columnar stromatolites may be found in reversed sequence due to migration of oolite shoals. (R. W. Owen and G. M. Friedman, 1984, Fig. 15, p. 233).

The evidence for deposition under tidal conditions for the Hoyt Limestone at Lester Park includes: (1) mud cracks, (2) flat-pebble conglomerate, (3) small channels, (4) cross-beds, (5) birdseye structures, (6) syngenetic dolomite, and (7) stromatolites (for characteristics on recognition of tidal limestones, see Friedman, 1969).

At Lester Park the heads which are circular in horizontal section range in diameter from one inch to three feet; many are compound heads. The size of the larger heads suggests that they formed in highly turbulent waters.

The line of depositional strike along which the domed stromatolites occur was probably where the waves were breaking as they came across the deeper ocean from the east and impinged on the shelf.

Several petrographic observations in these rocks permit an analogy with modern algal mats in hypersaline pools of the Red Sea Coast (Friedman and others, 1973). Mat-forming algae precipitate radial ooids, oncolites, and grapestones which occur in these rocks; interlaminated calcite and dolomite, which in part compose the stromatolites of the Hoyt Limestone, correspond to alternating aragonite and high-magnesium calcite laminites which modern blue-green algae precipitate. In modern algal mats the high-magnesium has been concentrated to form a magnesium-organic complex. Between the magnesium concentration of the high-magnesium calcite and that of the organic matter, sufficient magnesium exists in modern algal laminites to form dolomite. Hence the observation in ancient algal mats, such as observed in the Hoyt Limestone, that calcite and dolomite are interlaminated, with calcite probably forming at the expense of aragonite and dolomite forming from high-magnesium calcite.

		Turn around and drive back (south) to NY 29.
1.2	6.3	Turn right (west) on NY 29.
19.1	25.4	Turn left (south) on NY 30.
6.3	31.7	City limits of Amsterdam.
1.4	33.1	Cross bridge over Mohawk River.
0.1	33.2	Drive to Bridge Street (leaving NY 30 and turn north on Bridge Street); turn right on Florida Avenue and go west.
0.5	33.7	Turn right on Broadway.
0.8	34.5	Turn right (west) on NY 5S.
2.4	36.9	Fort Hunter, turn right (north) on Main Street.
0.2	37.1	Turn right (east) to Queen Anne Street.
0.9	38.0	Alight at slight bend in road and walk to Fort Hunter Quarry which is across rail-road track close to Mohawk River. (Fort Hunter Quarry cannot be seen from road; another small quarry visible from road is approximately 0.1 mile farther east, but will not be visited on this trip).

STOP 2. FORT HUNTER QUARRY

Stromatolites in the Fort Hunter Quarry consist almost entirely of dolomite in the form of irregularly bedded, finely-laminated, undulating structures (Figure 9). The rocks in this quarry are part of the Tribes Hill Formation of earliest Ordovician age (Fisher, 1954). The lithofacies of the Tribes Hill formation have been studied in detail by Braun and Friedman (1969) within the stratigraphic framework established by Fisher (1954). Figure 10 is a columnar section showing the relationship of ten lithofacies to four members of the Tribes Hill Formation. At Fort Hunter we will study the lowermost two lithofacies of the Fort Johnson Member (see column at right (east) end of section, in Fig. 10).

Two lithofacies are observed: (1) lithofacies 1, mottled feldspathic dolomite (Figure 10), and (2) lithofacies 2, laminated feldspathic dolomite. Lithofacies 1 is at the bottom of the quarry, and lithofacies 2 is approximately halfway up.

Lithofacies 1

This facies occurs as thin dolostone beds, 2 cm to 25 cm but locally more than 50 cm thick, with a few thin interbeds of black argillaceous dolostone which are up to 5 cm thick. In the field, the dolomite shows gray-black mottling and in places birdseye structures. In one sample, the infilling of the birdseyes shows a black bituminous rim which may be anthraxolite. In the field, trace fossils are abundant, but fossils were not noted. Authigenic alkali feldspar (microcline) is ubiquitous throughout this lithofacies; its identity as alkali feldspar was determined by X-ray analysis and staining of thin sections with sodium cobaltinitrite. The insoluble residue makes up 22 to 54% by weight of the sediment in samples studied with most of the residue composed of authigenic feldspar. An iron-poor yellow sphalerite may be occasionally found in the rocks of this lithofacies.

Lithofacies 2

This lithofacies is mineralogically identical to the previous facies but differs from it texturally and structurally in being irregularly bedded and in containing abundant undulating stromatolitic structures ("pseudo-ripples"), as well as disturbed and discontinuous laminae. In places there are a few thin interbeds of black argillaceous dolostone. The thickness of the laminites of this facies ranges from 1/2 mm to 2 or 3 mm; on freshly broken surfaces the color of the thinner laminae is black and that of the thicker ones is gray. The insoluble residue, for the most part composed of authigenic feldspar, constitutes between 35% and 67% by weight in samples studied.

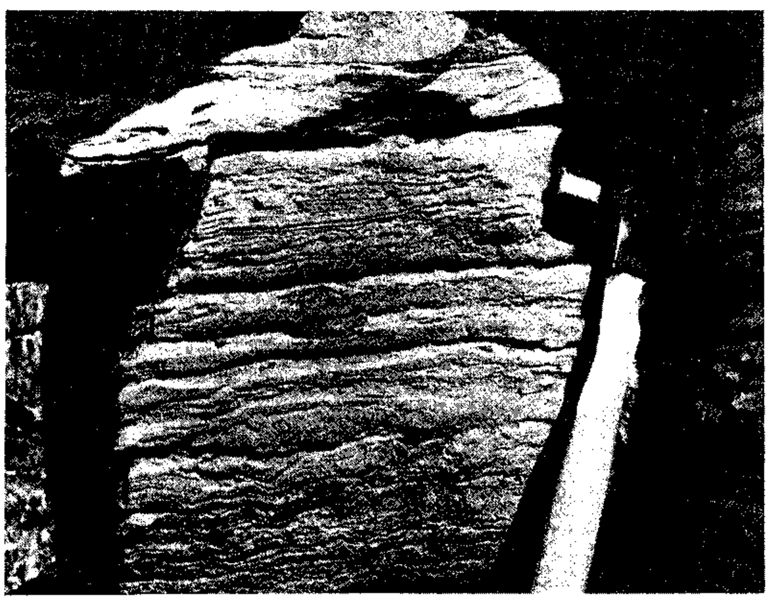


Figure 9. Stromatolite structures of lithofacies 2 (laminated feldspathic dolomite), Tribes Hill Formation (Lower Ordovician), Fort Hunter, New York. (M. Braun and G. M. Friedman, 1969, Fig. 3, p. 117; G. M. Friedman, 1972, Fig. 5, p. 21.)

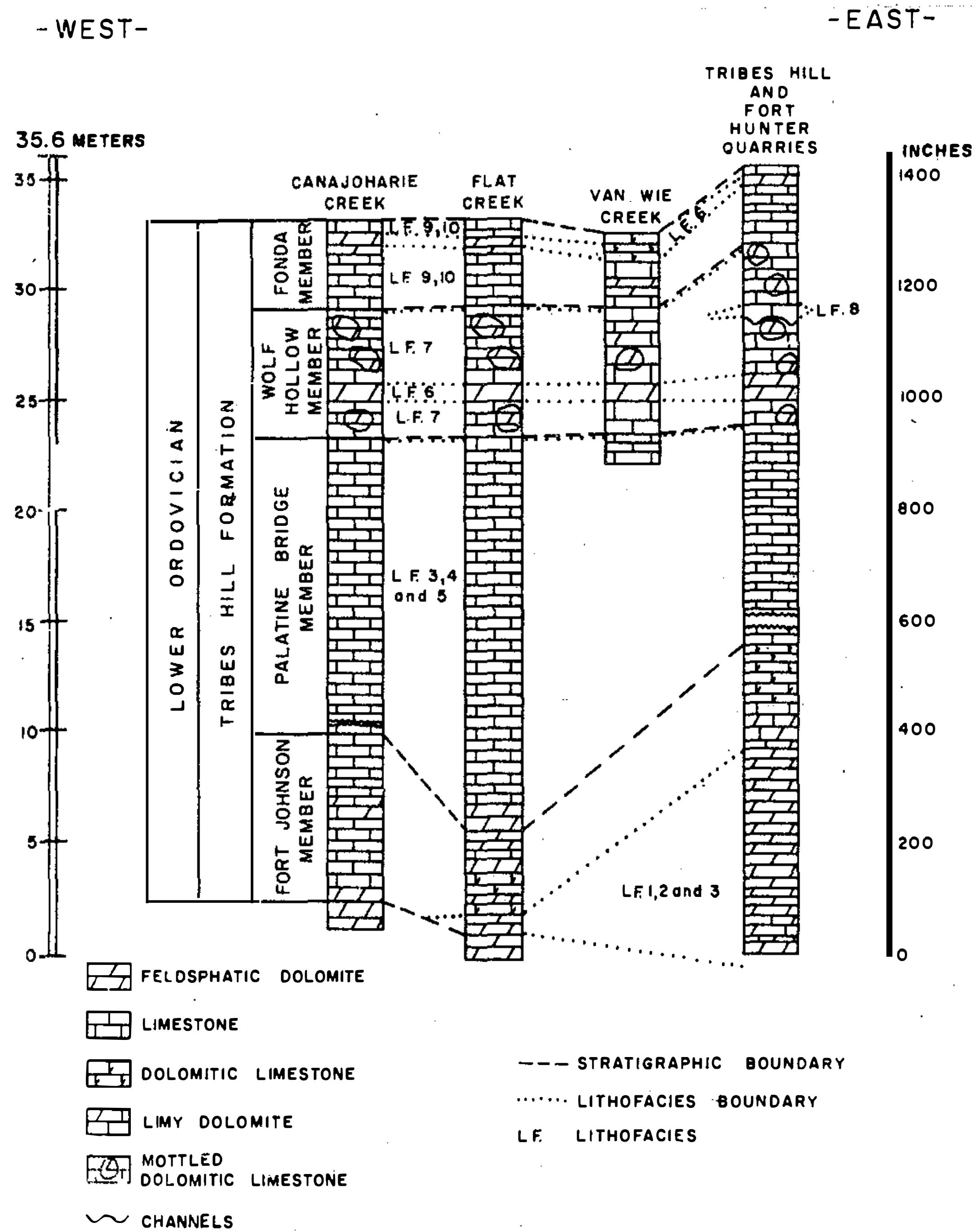


Figure 10. Columnar section showing the relationship of ten lithofacies to four members in Tribes Hill Formation (Lower Ordovician) (after Braun and Friedman, 1969; Friedman, 1972, p. 19, Fig 4.)

These two lithofacies which form the basal unit of the Ordovician, were formed on a broad shallow shelf. Stromatolites, birdseye structures, scarcity of fossils, bituminous material, syngenetic dolomite, authigenic feldspar, and mottling suggest that these rocks were deposited in a tidal environment (Friedman, 1969). Based on analogy with the carbonate sediments in the modern Bahamas, Braun and Friedman (1969) concluded that these two lithofacies formed under supratidal conditions. However, in the Persian Gulf flat algal mats prefer the uppermost intertidal environment and along the Red Sea coast they flourish where entirely immersed in seawater, provided hypersaline conditions keep away burrowers and grazers (Friedman and others 1973). Hence on this field trip we may conclude that the stromatolites indicate tidal conditions without distinguishing between intertidal and supratidal. For more details on these lithofacies refer to Braun and Friedman (1969).

		Turn around and drive back to Main Street, Fort Hunter.
0.9	38.9	Turn right (north) onto Main Street, Fort Hunter.
0.1	39.0	Cross original Erie Canal, built in 1822. Amos Eaton surveyed this route at the request of Stephen Van Rensselaer; after this survey Amos Eaton and Van Rensselaer decided to found a school for surveying, geological and agricultural training which became Rensselaer Polytechnic Institute. Follow Main Street through Fort Hunter.
0.6	39.6	Cross Mohawk River.
0.5	40.1	Turn right (east) on Mohawk Drive (town of Tribes Hill).
0.4	40.5	Turn left (north) on Stoner Trail.
0.2	40.7	Cross Route 5 and continue on Stoner Trail.
2.7	43.4	Turn right (east) on NY 7.
1.5	44.9	Fulton-Montgomery Community College, continue on NY 67.
1.6	46.5	Alight at North Tribes Hill quarry (on left).

STOP 3. NORTH TRIBES HILL QUARRY

Route of Walk

Take the trail toward old abandoned crusher, but instead of heading toward the quarry move uphill to the first rock exposures. The rocks to be examined are near the edge of steep cliff.

Description and Discussion

In the rocks at this exposure the field relationships show typical channels truncated at their bases. Lodged within the channels are limestone blocks of variable shape ranging in diameter from about one to three feet. These blocks resemble similar blocks in tidal channels of the Bahamas which are derived by undercutting of the banks of the tidal channels. The blocks at this exposure are rounded, suggesting that they have undergone some transport.

The rocks composing the channel (the channel fill) and the blocks of rock within the channels have been described as lithofacies 8 (Figure 11) (channel fill) and lithofacies 7 (Figure 12) (blocks) of the Wolf Hollow Member of the Tribes Hill Formation (lowermost Ordovician) (see columnar section of Fig. 10); column at right end of the section) (Braun and Friedman, 1969). The channel fill (lithofacies 8) consists of intrasparite and biointrasparite with sporadic ooids, a high-energy facies, whereas the blocks (lithofacies 7) consist of mottled dolomitic micrite and biomicrite, a low-energy facies of the undercut bank. The micrite blocks which foundered in the channels must have been indurated penecontemporaneously (Fig. 13).

		Turn around on NY 67 and go west.
3.1	49.6	Turn left onto Stoner Trail.
2.7	52.3	Take Route 5 towards Amsterdam. Upon reaching NY 30 turn right (south) and continue south on NY 30.
Approx. 50.0	Approx. 102.0	Turn left (east) on road to Gilboa; stop before bridge.
1.0	103.0	Stop 4

Middle to Upper Devonian Peritidal Deposits

STOP 4. MARSH FACIES

No examples of the marsh facies have been found in situ. However, giant seed ferns of the Gilboa Forest (Goldring, 1924, 1927), which grew in a marsh environment, were discovered in the now-inactive Riverside Quarry near here. More than 200 stumps were taken from this single quarry; some of these have been placed at this site, others are now preserved in museums. The "trees" of Gilboa Forest are among the world's oldest; they grew in a marsh environment of the Catskill Deltaic complex. The bulbous bases of these fossils were found in place in dark-colored shale; the upright trunks were encased in olive-gray, cross-bedded sandstone of probable tidal origin. The age of the "trees" is latest Middle Devonian.

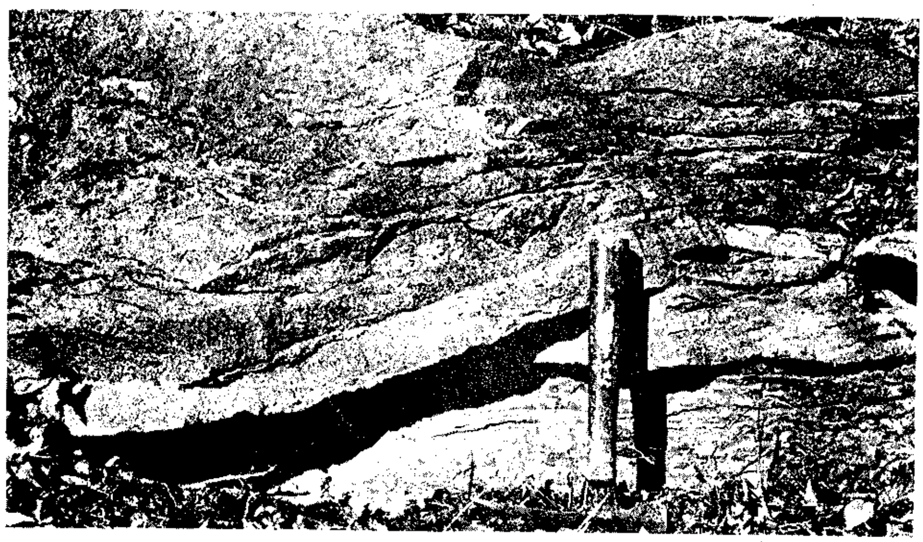


Figure 11. View perpendicular to strata of limestone showing worn and abraded block (light grey) of mottled dolomitic micrite, which is thought to have foundered from eroded bank of ancient tidal channel. Darker grey enclosing rock (intrasparite and biointrasparite). Tribes Hill Formation (Lower Ordovician), North Tribes Hill Quarry (G. M. Friedman and J. E. Sanders, Fig. 11-51, p. 342).

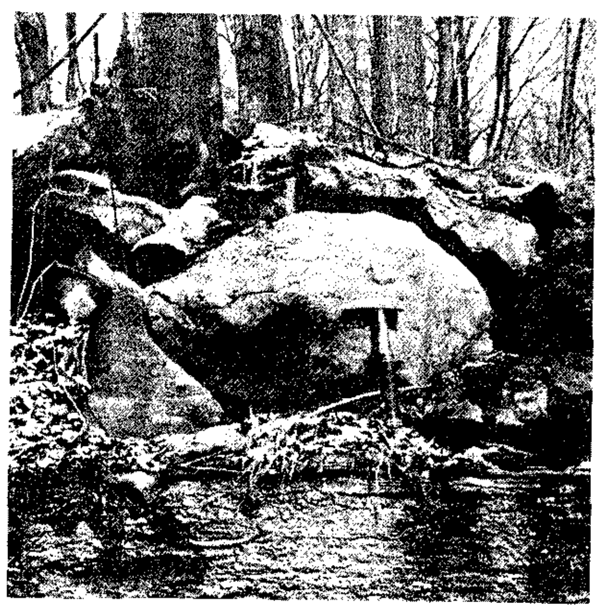


Figure 12. Truncation at base of tidal channel. Rocks in channel consist of lithofacies 8 (intrasparite and biointrasparite), Tribes Hill Formation (Lower Ordovician). North Tribes Hill quarry.

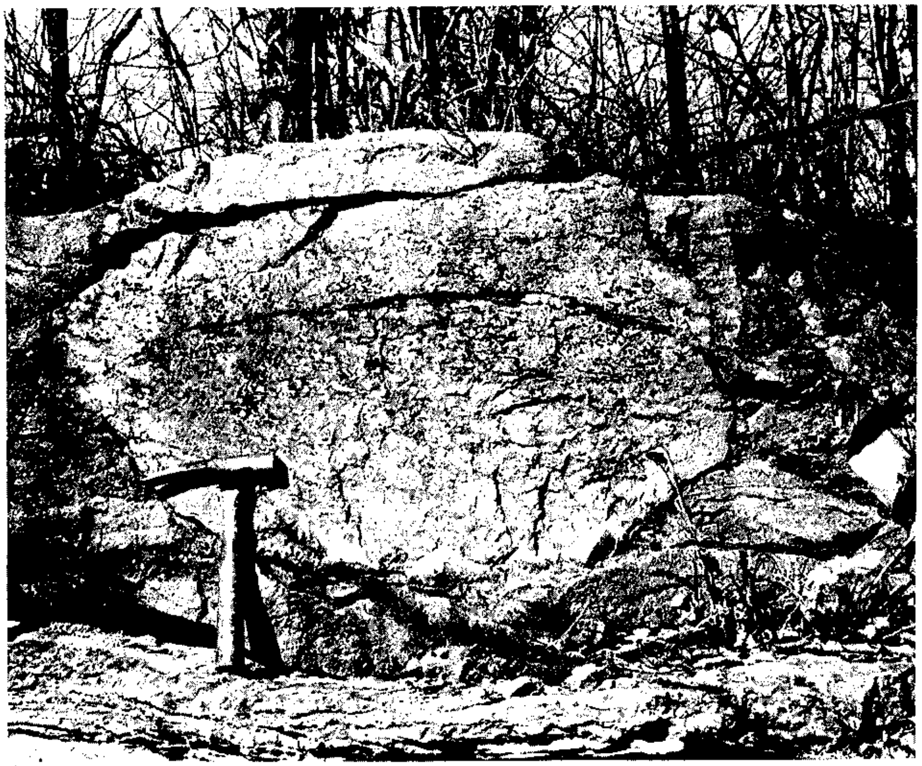


Figure 13. Block of lithofacies 7 (mottled dolomitic micrite and biomicrite) foundered in tidal channel (lithofacies 8), Tribes Hill Formation, (Lower Ordovician). North Tribes Hill quarry.

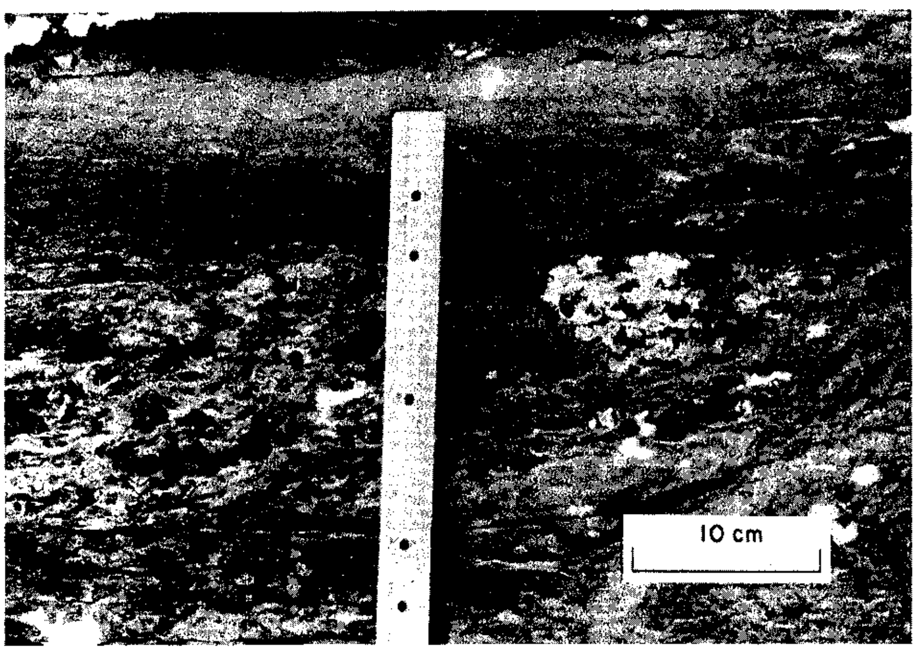


Figure 14. Ancient shell hash that has been deposited at base of tidal channel (margin of channel at lower right); most fossils (here represented by molds and thus appearing as irregular black areas) are of brachiopods. Middle of Upper Devonian, Catskill Mountains, Grand Gorge (Stop 5). (K. G. Johnson and G. M. Friedman, 1969, Fig. 22, p. 475.)

Return to NY 30.

1.0	104.0	Turn left (south) on NY 30.
0.8	104.8	Here is Stop 5, the Grand Gorge Section.

STOP 5. INTERTIDAL FACIES: TIDAL FLATS AND TIDAL CHANNELS

The rocks at this exposure are medium-gray, fine-grained graywackes; tabular cross-beds are ubiquitous, parting lineations are common. The most interesting single feature at this exposure are the tidal channels. These channels are small, about 2 to 10 feet in cross-section; they truncate the underlying strata. The channel fill consists mostly of a lag concentration of transported spiriferid brachiopod shells (Figure 14). Usually the shell material is abundant enough to rate for the channel the name "coquinite." Holes in the coquinites are brachiopod molds. Interestingly, brachiopod shells are confined only to the coquinite lenses; they are not found in the surrounding rock. Hence the brachiopods were treated by the channels as pebbles that were washed in from the open marine environment. In analogous modern tidal channels, typical open sea species are washed into the channels by flood tides (Van Straaten, 1956).

An alternate interpretation for the coquinite lenses is that they may be storm deposits. The lenses are lag concentrates of brachiopod shells; in the contiguous sandstones pelecypods, chiefly Unio, occur. If these lenticular coquinite lenses were tidal channels, then according to this alternate interpretation, lateral cutting should have concentrated the molluscs. Yet these lenses are devoid of molluscs, hence storms rather than tidal action should have caused the coquinite lenses.

Load-flow structures, formerly known as ball-and-pillow structures, load casts or storm rollers are locally present. They represent compactional differential loading. These structures may be related to slumping and are common on the front of modern deltas.

Note that the next exposure south (uphill) is composed of red fluvial rocks.

This exposure has been described by Johnson and Friedman as part of their section 43 (1969, p. 471-475, especially Figs. 22 and 23). These rocks are the clastic correlatives of the Tully Limestone (early Late Devonian or latest Middle Devonian).

Continue south on NY 30.

1.8	106.6	Turn right (west) on NY 23 to Stamford.
7.4	114.0	Turn right (north) on NY 10 through Summit.
16.1	130.1	Stop at roadcut behind sign "Town of Richmondville" (3.5 miles north of Summit).

STOP 6. DEPOSITS OF LAGOONS AND BARS OR TIDAL DELTAS

At this exposure lenticular sandstone bodies interfinger with dark-gray siltstones and shales. The sandstones have a vertically shingled, or en echelon, configuration relative to one another. Even the thickest sandstone, approximately 6 feet thick, thins and pinches out laterally (see Fig. 25, p. 478 in Johnson and Friedman, 1969). The sandstones contain marine fossils and wood fragments. In places they are crossbedded; ripple marks are locally present. In the siltstones and shales wood fragments are abundant. The presence of marine fossils, the absence of channels, and the lenticular geometric configuration of the sandstones within interfingering siltstones or shales suggests that the sandstones may be bars or tidal deltas. If so, the siltstones or shales are of lagoonal origin.

The rocks at this exposure belong to the Hamilton Group (Middle Devonian) and are about 600 feet below the stratigraphic level of the Tully clastic correlatives.

Approx.	Approx.	
48.0	178.0	Continue north on NY 10 to NY 7 and return (east) to Skidmore College.

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