CARBONATE AND TERRIGENOUS SEDIMENTARY FACIES OF TIDAL ORIGIN, EASTERN NEW YORK

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INTRODUCTION

This is a field trip to study sedimentary facies of tidal origin. At each exposure we shall study the rocks in terms of lithology, geometry, sedimentary structures, and fossils and concentrate on the pattern of deposition which created the facies. In this kind of approach the name and age of the formation becomes secondary; hence this field trip has been designed irreverently; it pays no heed to formation boundaries. Facies analysis will proceed within the boundary conditions of each single exposure.

During Cambrian to Lower Ordovician time, most of the North American continent was a shallow epeiric carbonate shelf, like the present-day Bahama Bank. At the eastern margin of this shelf, i.e. at the eastern margin of this continent, a relatively steep slope existed down which carbonate sediment moved by slides, slumps, turbidity current, mud flows, and sand falls to oceanic depths (Sanders and Friedman, 1967, p. 240-248; Friedman, 1972). We shall visit shallow-water carbonates shelf deposits which accumulated 30 to 40 miles west of the steep paleoslope which existed during Cambrian to Lower Ordovician times. These shallow-water epeiric carbonate sediments, located in such close proximity to a major ocean, were under the effects of tidal currents. On this field trip we shall examine products of tidal sedimentation on this Cambrian to Lower Ordovician carbonate shelf. For details on the stratigraphy of these carbonate deposits reference should be made to Fisher (1954, 1965) and Braun and Friedman (1969), and on the depositional environments to Braun and Friedman (1969), Friedman (1972), Buyce and Friedman (1975), and Friedman and Braun (1975), and Mazzullo and Friedman (1975, 1977).

Coincident with and after the Acadian orogeny during Middle and Late Devonian times huge river systems of a "tectonic delta complex" (Friedman and Johnson, 1966) drained the area which is now the site of the Catskill Mountains. Devonian rocks, of braided and meandering stream origin, interfinger with those of tidal, nearshore and offshore origin. We shall examine the tidal deposits, all of which are terrigenous. For details on the stratigraphy and depositional environments of the rocks of the tectonic delta complex reference should be to Johnson and Friedman (1969); some reinterpretations have been offered by Friedman (1972).

ITINERARY

Each stop describes and interprets the sedimentary facies; hence each stop should be regarded as self contained. Figure 1 is the road log and shows the location of all the six stops visited.

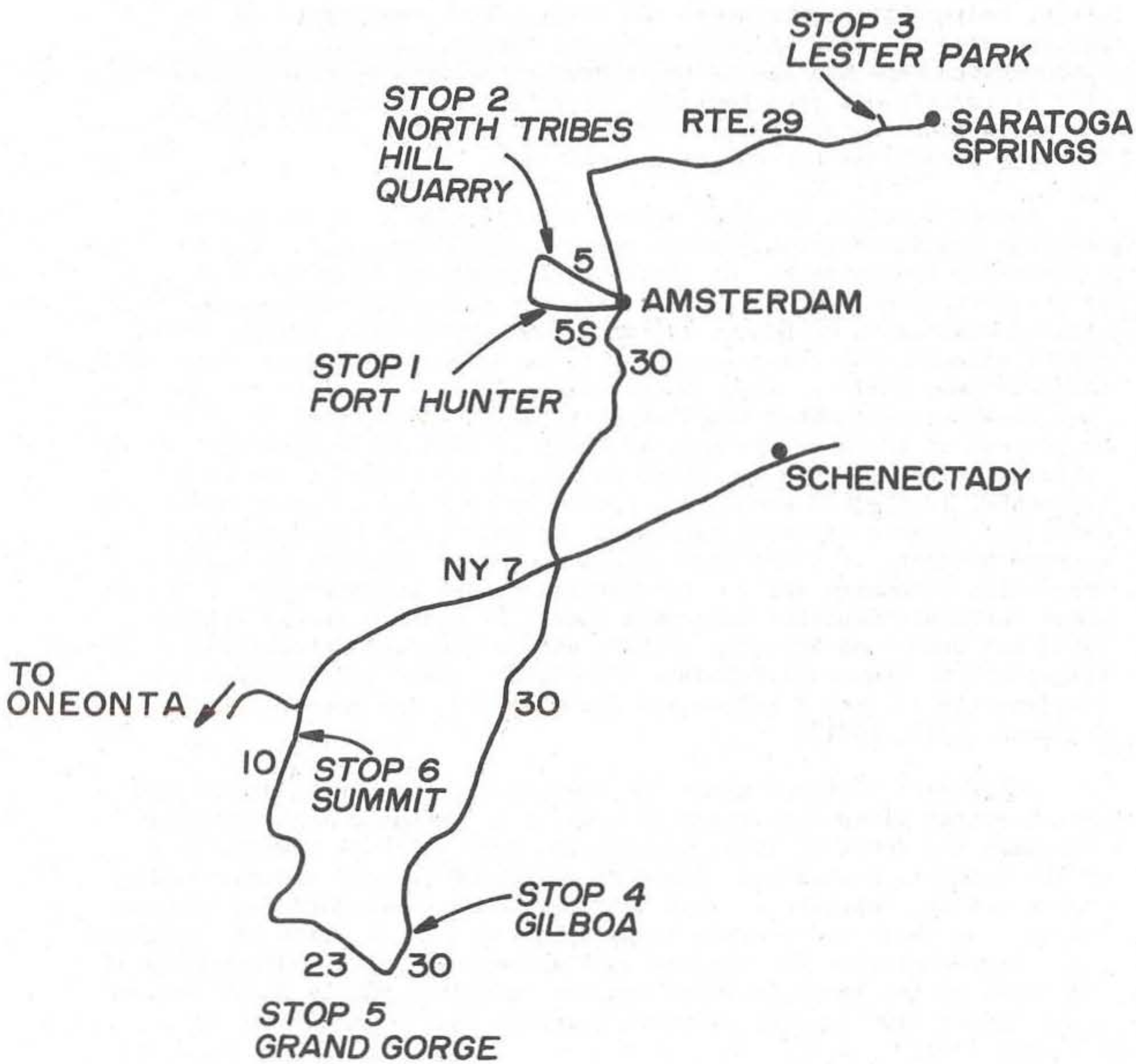

Fig. 1. Road log with stops. Scale: 1 inch = approximately 12 miles. Numbers refer to Highways.

Miles from last point	Cumulative Miles	
0.0	0.0	Depart Oneonta and follow NY 7 to junction NY 30.
4.1	4.1	Turn left (north) on NY 30; cross NY 20.
13.7	17.8	Continue on NY 30 to junction with NY 5S on outskirts of Amsterdam and close to entrance of New York Throughway.
4.0	21.8	Turn left (west on NY 5S and proceed to Fort Hunter; Fort Hunter, turn right (north) on Main Street;
0.2	22.0	Turn right (east) to Queen Ann Street.
0.9	22.9	STOP 1. FORT HUNTER QUARRY. Alight at slight bend in road and walk to Fort Hunter Quarry which is across railroad 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 1. Products of Tidal Environment: Flat Algal Mats

Stromatolites in the Fort Hunter Quarry consist almost entirely of dolomite and feldspar in the form of irregularly bedded, finely-laminated, undulating structures. 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 2 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. 2).

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

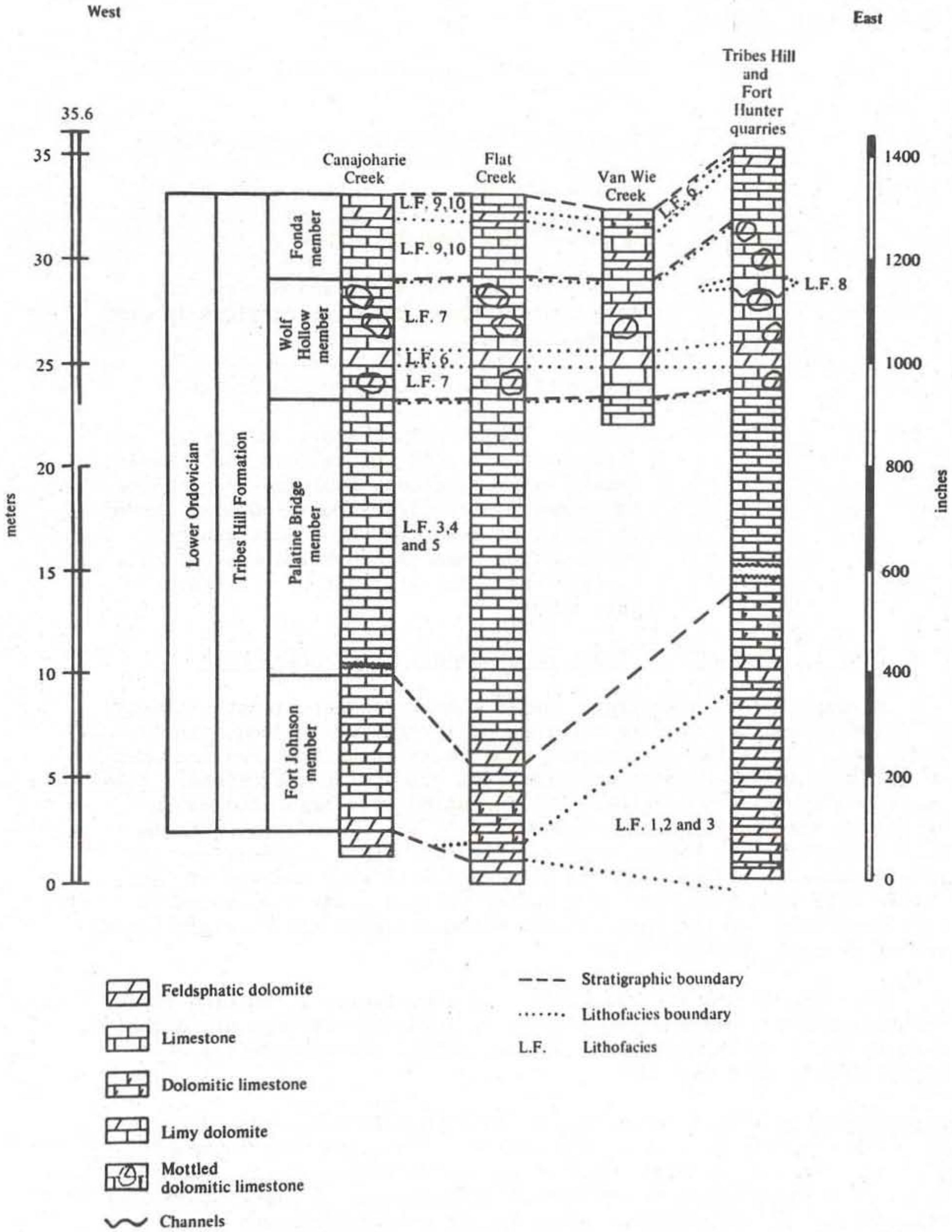

Fig. 2. Columnar section showing the relationship of ten lithofacies to four members of Tribes Hill Formation (Lower Ordovician) (after Braun and Friedman, 1969; Friedman, 1972).

feldspar (microline) is ubiquitous throughout this lithofacies; its identity as alkali feldspar was determined by x-ray analysis and staining of a thin section 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.

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 laminations. 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.

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).

Trip Continued

Miles from last point	Cumulative Miles	
		Turn around and drive back to Main Street, Fort Hunter.
0.9	23.8	Turn right (north) into Main Street, Fort Hunter.
0.1	23.9	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.

Miles from last point	Cumulative Miles	
0.6	24.5	Cross Mohawk River.
0.5	25.0	Turn right (east) on Mohawk Drive (town of Tribes Hill).
0.4	25.4	Turn left (north) on Stoner Trail.
0.2	25.6	Cross Route 5 and continue on Stoner Trail.
2.7	28.3	Turn right on NY 67 (east).
1.5	29.8	Fulton-Montgomery Community College; continue on NY 67.
1.6	31.4	STOP 2. NORTH TRIBES HILL QUARRY (on left).

Stop 2. Products of Tidal Channels

Route of Walk. - Take the trail towards old abandoned crusher, but instead of heading towards 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 (fig. 3). 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 (i.e. the channel fill) and the blocks of rock within the channels have been described as lithofacies 8 (channel fill) and lithofacies 7 (blocks) of the Wolf Hollow Member of the Tribes Hill Formation (lowermost Ordovician) (see columnar section of fig. 2; column at the 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.

Hence during earliest Ordovician time high-energy tidal channels crisscrossed tidal flats at this site. In them water coming from the deep ocean to the east rose and fell with the changing tides.

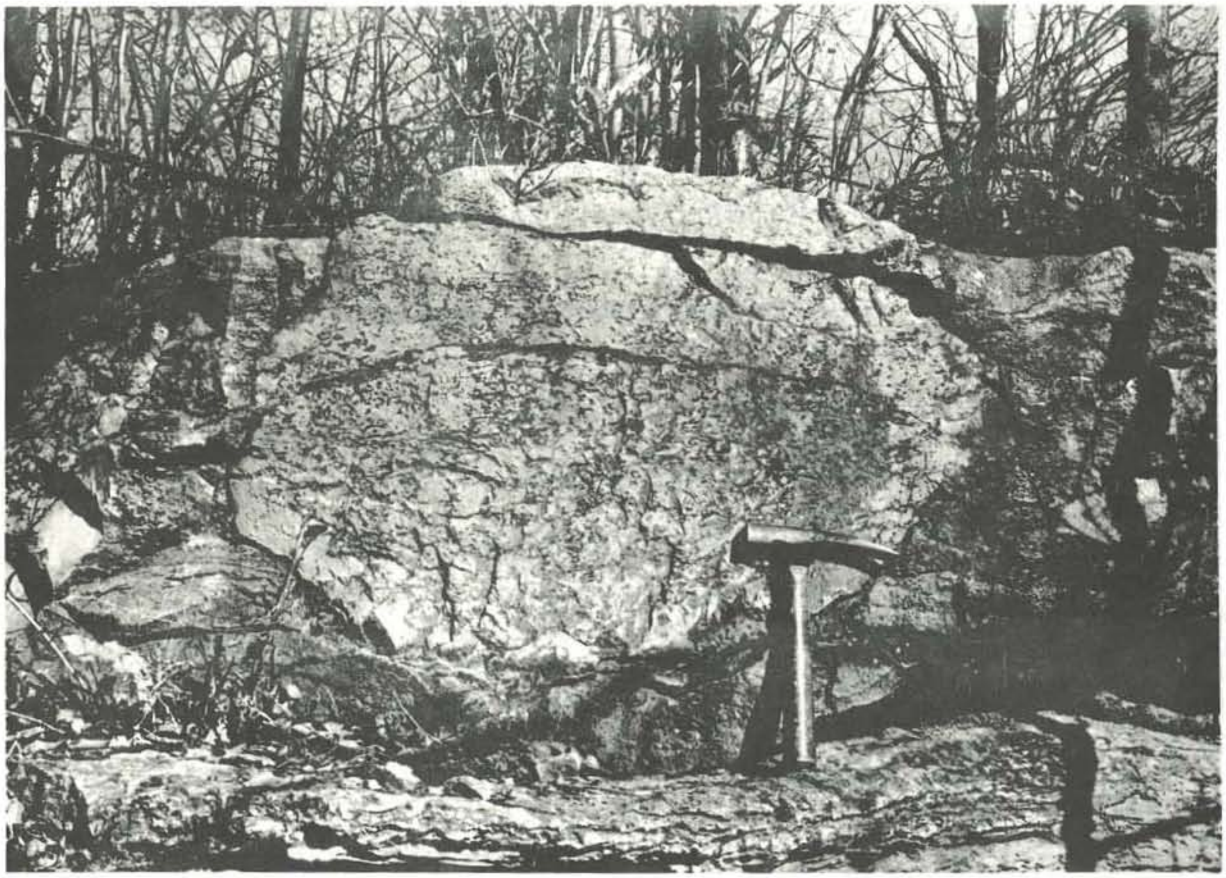

Fig. 3. View perpendicular to strata of limestones showing worn and abraded block (light gray) of mottled dolomitic micrite (lithofacies 7 of Tribes Hill Formation, Lower Ordovician, of Braun and Friedman, 1969, and Friedman and Braun, 1975) which is thought to have foundered from eroded bank of ancient tidal channel. Darker gray enclosing rock is intrasparite and biointrasparite (lithofacies 8 of Tribes Hill Formation of Braun and Friedman, 1969, and Friedman and Braun, 1975). North Tribes Hill Quarry (Stop 2).

Trip Continued

Miles from last point	Cumulative Miles	
		Continue east on NY 67 (through Village of Fort Johnson);
1.8	33.2	Turn left (east) on NY 5;
1.0	34.2	City of Amsterdam; turn left (north) on NY 30
6.3	40.5	Turn right (east) on NY 29
19.1	59.6	Continue on NY 29 to Petrified Garden Rd. Drive past "Petrified Gardens" to Lester Park.
1.2	60.8	Alight at Lester Park

STOP 3. LESTER PARK

Stop 3. 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 algal layers. 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; Owen, 1973). The algal heads are composed of discrete club-shaped or columnar structures built of hemispheroidal algal mats expanding upward from a base, although continued expansion may result in the fusion of neighboring colonies into a Collenia-type structure (Logan, Rezak and Ginsburg, 1964). The algal mats are part of the Hoyt Limestone of Late Cambrian (Trempealeauan) age. Their intertidal origin has been inferred by (1) observations in the rocks, and (2) by analogy with similar modern algal heads.

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 criteria on recognition of tidal limestones, see Friedman, 1969). The analogy with modern environments relates to the occurrence of cabbage-shaped algal heads in the intertidal zone of Shark Bay, western Australia, in which the height of the domes is controlled by the degree of turbulence (Logan, Rezak and Ginsburg, 1964; Hoffman, Logan and Gebelein, 1969). With increasing wave and current energy the height of the domes increases; the relief of the domes decreases landward towards quieter water conditions.

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 algal mats occur was probably where the waves were breaking as they came across the deeper ocean from the east and impinged on the shallow 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 grapesteons 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-magnesian calcite laminites which modern blue-green algae precipitate. In modern algal mats the high-magnesium calcite laminites contain abundant organic matter in which 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.

Trip Continued

Miles from last point	Cumulative Miles	
		Turn around and drive back (south) to NY 29.
1.2	62.0	Turn left (west) on NY 29
19.1		
6.3	87.4	City limits of Amsterdam
1.4	88.8	Cross bridge over Mohawk River
13.7	102.5	Continue on NY 30; junction with NY 20
4.1	106.6	Cross NY 7; continue on NY 30
4.5	111.1	Schoharie
4.7	115.8	Cross NY 145 at Middleburg; continue on NY 30

Miles from last point	Cumulative Miles	
7.0	122.8	Cross Schoharie Creek
5.9	128.7	North Blenheim
6.5	135.2	Turn left (east) on road to Gilboa; stop before bridge
1.1	136.3	STOP 4. GILBOA FOREST

Stop 4. Tidal Marsh Facies

No examples of this tidal 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 (Fig. 4). 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 (New York State Museum, Albany; Geological Museum, Rensselaer Polytechnic Institute). The "trees" of Gilboa Forest are among the world's oldest; they grew in a tidal 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 probably tidal origin. The age of the "trees" is latest Middle Devonian.

Trip Continued

Miles from last point	Cumulative Miles	
1.1	137.4	Return to NY 30
0.7	138.1	Turn left (south) on NY 30
		STOP 5. 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 (Fig. 5). 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 concentrate of transported spiriferid brachiopod shells. Usually the shell material is abundant enough to rate for the channel the name "coquinite." Holes in the coquinites are molds of brachiopods. 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).

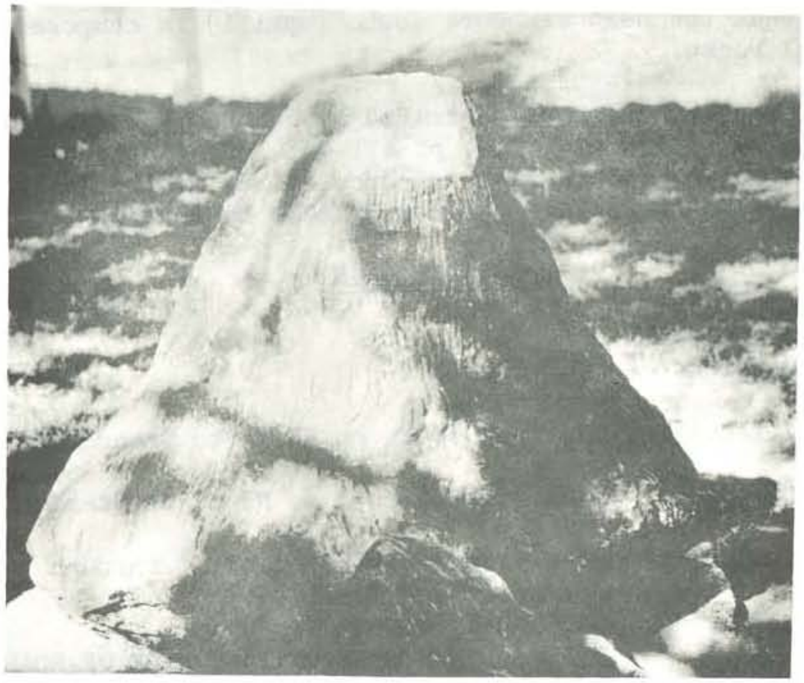

Fig. 4. Bulbous base of giant seed tree which grew in tidal marsh of Gilboa Forest. Latest Middle Devonian. Stop 4.

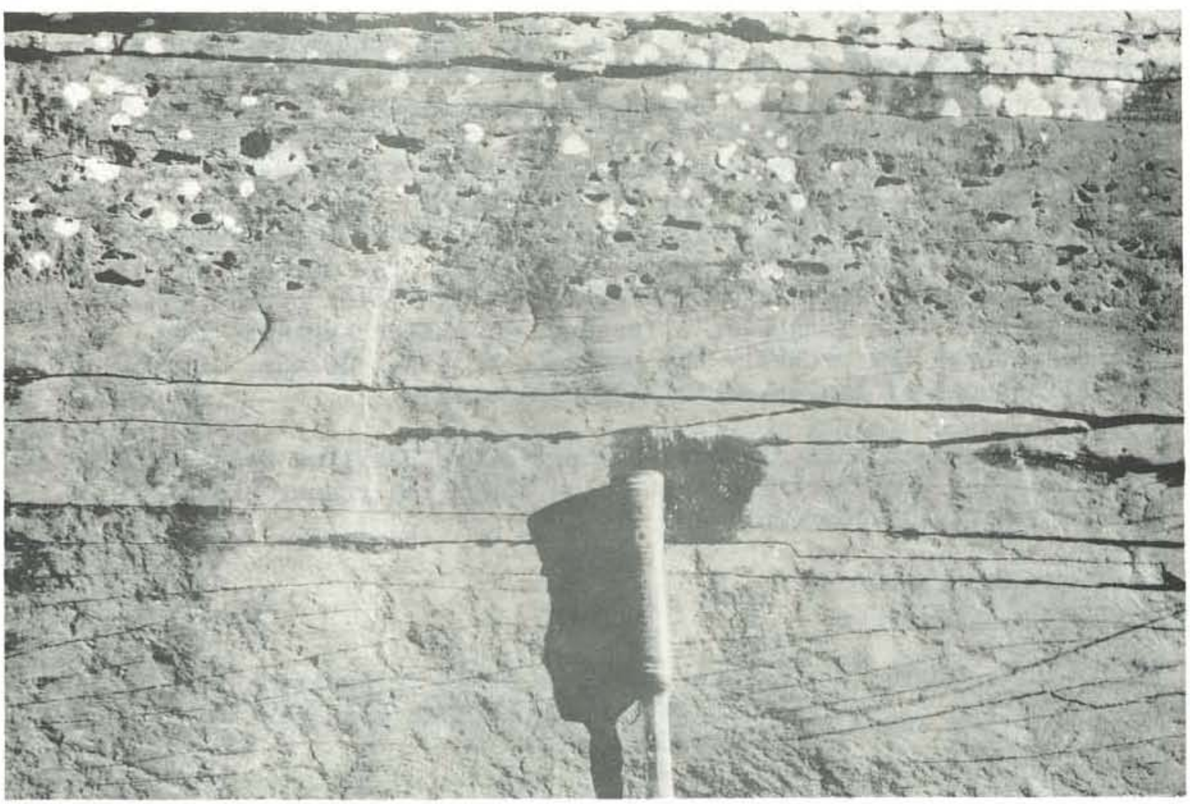

Fig. 5. View perpendicular to strata of sandstones showing low angle cross-bedding (lower part of photograph) and lag concentrate of transported spiriferid brachiopod shells with abundant molds (upper part of photograph). Inferred tidal channel. Early Late to latest Middle Devonian. Stop 5.

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).

Trip Continued

Miles from last point	Cumulative Miles	
2.0	140.1	Continue south on NY 30 to Grand Junction
8.4	148.5	Turn right (west) on NY 23 to Stamford
17.2	165.7	Turn right (north) on NY 10 through Jefferson and Summit
		STOP 6. EXPOSURE ON EAST SIDE OF ROAD
		(Richmondville; 3.5 mi. north of Summit)

Stop 6. Deposits of Tidal Deltas and Lagoons

At this exposure lenticular sandstone bodies interfinger with dark-gray siltstones and shales (Fig. 6). 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 are probably the products of 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.

Miles from last point	Cumulative Miles	
35.0	201.0	Continue north on NY 10 to junction with NY 7 (1.5 miles) and then head west on NY 7 to Oneonta.

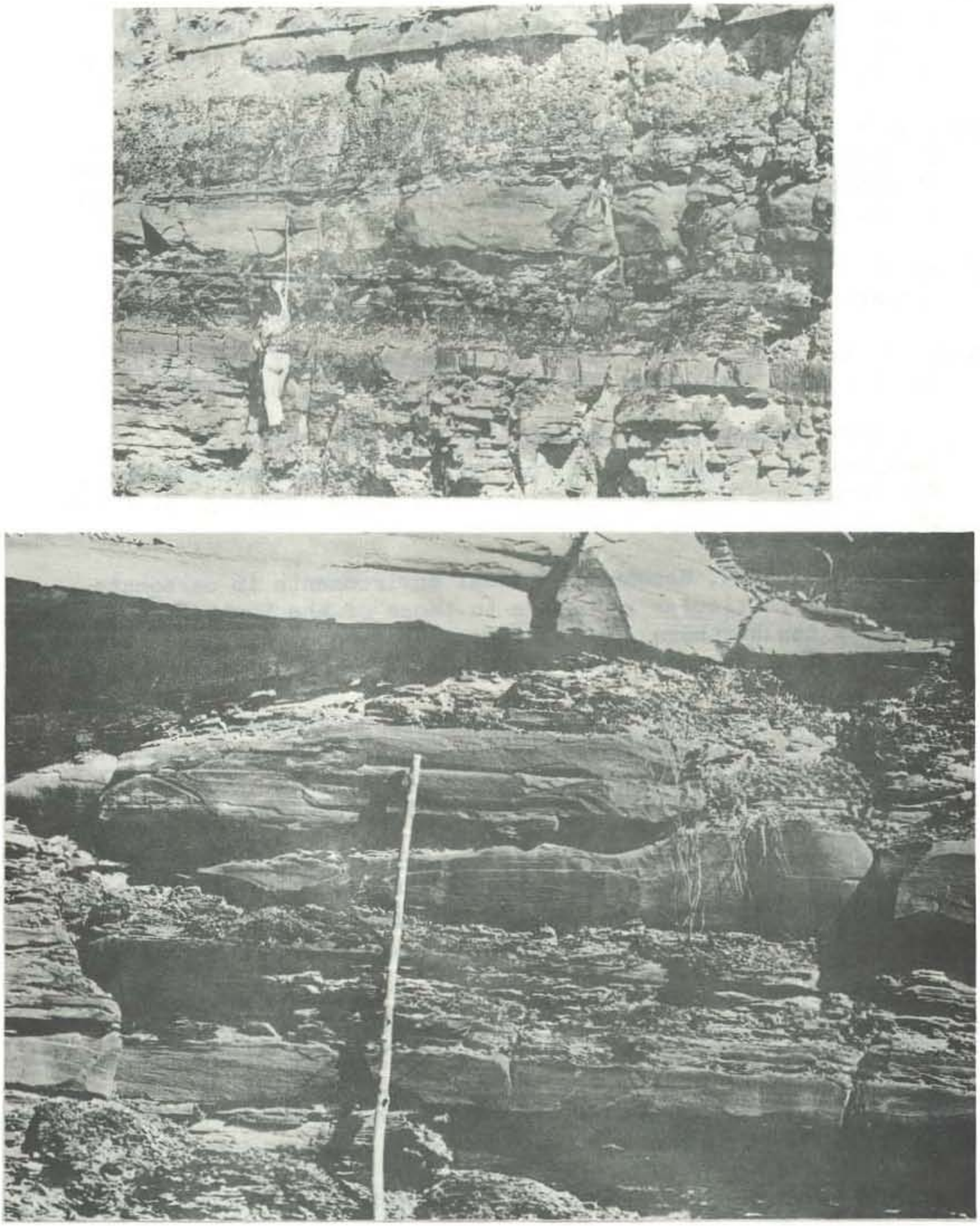

Fig. 6. Two views perpendicular to lenticular sandstone bodies interfingering with dark-gray siltstones and shales. The sandstones are inferred to be the products of tidal deltas; the sandstones and shales are thought to be of lagoonal origin. Hamilton Group (Middle Devonian). Stop 6.

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