ICHNOFOSSILS

of the

TULLY CLASTIC CORRELATIVES IN EASTERN NEW YORK STATE

by

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INTRODUCTION

Within the clastic correlatives of the Tully Limestone in eastern New York State there occurs a remarkably complete spectrum of ancient sedimentary facies (Johnson and Friedman, 1969; Johnson, 1968, 1970, 1972, 1976). These beds, which evolved during a transgressive pulse in the building of the great Catskill deltaic system, are part of a 3000 meter (10900') sequence that constitutes the standard for the Devonian System of North America (Figs. 1 and 2). They are exposed at the northeastern end of the Allegheny Synclinorium, are essentially undisturbed and, for the most part, very fossiliferous. Laterally transitional between those beds that are clearly of marine origin and those that are clearly non-marine are sandstones and shales that have sedimentary structures, lithology, geometric relationships with adjacent units and biogenic structures that indicate that they evolved in tidal and shallow sub-tidal environments.

The purpose of this field trip is to focus on one aspect of the evidence used to develop environmental assignments for the Tully clastic correlatives; namely, biogenic structures.

LITHOFACIES of the MIDDLE AND UPPER DEVONIAN

Three general lithofacies are recognized in the Devonian deltaic system of New York State (Fig. 2). The Catskill lithofacies, which consists of non-marine red and green-gray shales, sandstones and conglomerates, overlies and interfingers westward with littoral and shallow marine, very fossiliferous, gray sandstones and shales of the Chemung lithofacies. The Chemung, in turn, overlies and interfingers westward with deeper-water, sparsely fossiliferous, black shales of the Portage lithofacies. All of the exposures to be examined during this trip are within the eastern Chemung lithofacies. Stops 1 through 5 are in the Schoharie Valley, around Schoharie Reservoir. Stops 6 through 10 lie between the Schoharie Valley and the Unadilla Valley to the west.

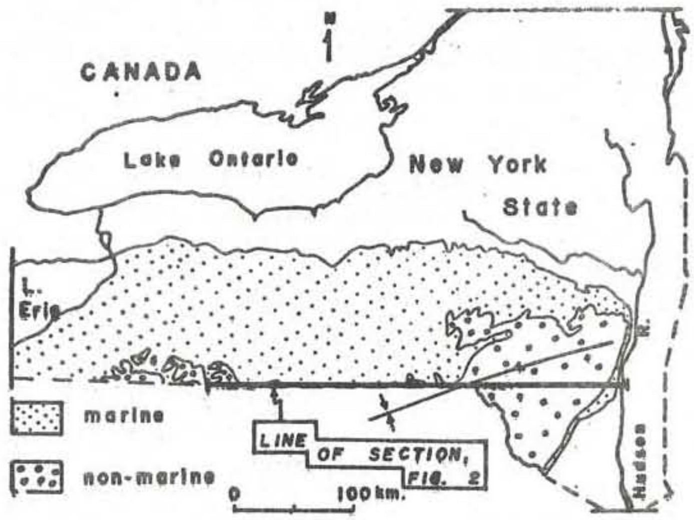

Figure 1 - Devonian bedrock of New York State (after Rickard, 1964).

CHARACTERISTICS OF EASTERNMOST CHEMUNG LITHOFACIES

In the Schoharie Valley the Catskill and Chemung lithofacies are interbedded and well exposed. The following represents a summary of the lithologic, sedimentologic and paleontologic characteristics of the Chemung beds in the vicinity of Gilboa Dam.

Lithology

Lithologies within the Chemung lithofacies are interlensing medium gray (N4) to dark gray (N3), micaceous siltstone and shale and medium gray (N5), very fine-grained sandstone with subordinate, medium gray (N5 and N6) coquinite lenses (color terminology is that of Goddard, 1951). All of the sandstones of the lithofacies are submature and immature graywackes following the usage of Folk (1954, 1965). They contain sporadic accumulations of shale pebbles as well as moderately common, small pyrite nodules. A few polymictic pebble conglomerates containing pebbles of light gray and greenish gray quartzite, medium gray slate, red and olive siltstone, and subordinate medium gray limestone are present. Siltstones and shales of the lithofacies are dark gray in color due to a high content of fine organic material. They are very micaceous and variably thinly cross-laminated to occasionally fissile.

The coquinites, or in most examples more correctly coquinoid sandstones, occur as elongate lenses ranging from a few centimeters thick by 1 or 2 m long to 15 to 45 cm thick by lengths of up to some 15 meters.

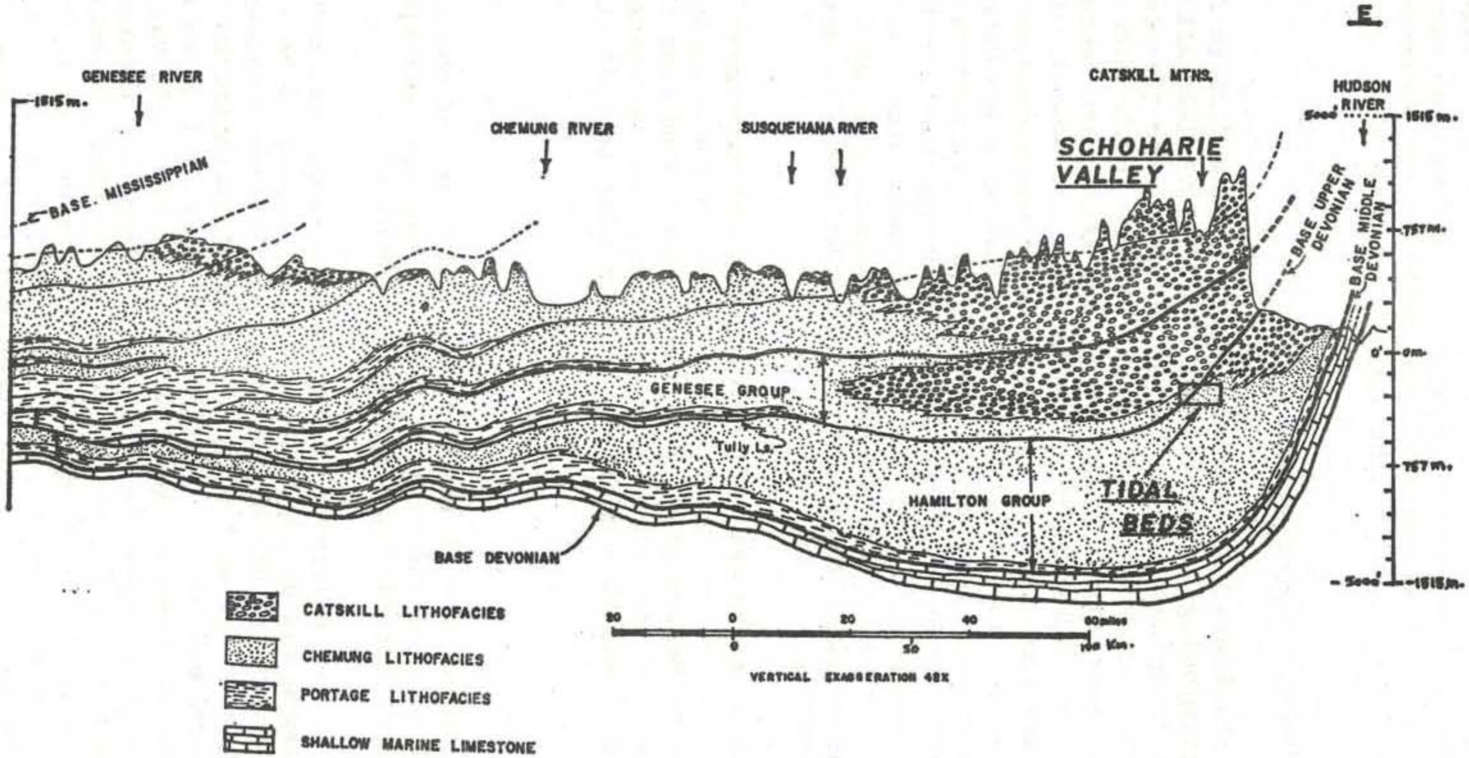

Figure 2 - Cross section of Devonian System along New York-Pennsylvania border (modified after Fig. 17, Broughton and others, 1962).

Thickness within a given lens is variable and they rest in channelled contact on underlying beds. Shell material in the lenses consists mostly of large spiriferid brachiopods, which in most fresh exposures are composed of calcium carbonate. Some of the lenses also contain pelecypod fragments as well as red siltstone pebbles. No preferred orientation of valves is apparent in the lenses, although some valves suggest imbrication.

Inorganic Sedimentary Structures

Bedding thickness of sandstones ranges from medium to thick and very thick (terminology after Ingram, 1954). Virtually all of the strata in the lithofacies, with the exception of the fissile shales, are cross-bedded or cross-laminated. Even the very thick-bedded sandstones, which in some cases appear homogeneous, are well cross-laminated. Interference, oscillation and current ripple marks are common. Interference ripple marks are expressed as a low-amplitude unevenness on bedding surfaces. The current and oscillation ripple marks, which have wave lengths of several centimeters and amplitudes of only 2 centimeters or less, provide reliable and plentiful evidence of sedimentary strike and direction of transport. Cross-bedding is of both planar and trough types and in most cases the inclination of foresets is well in excess of the 10 degree lower limit used by Pettijohn (1962) to denote high-angle cross-bedding.

Dessication cracks are well developed in the uppermost part of the Hamilton Group in the Schoharie Valley. Most of these occur as polygonal patterns of medium gray, very fine-grained sandstone infill on bedding surfaces of dark gray shaly siltstone. In one instance numerous sandstone infills extend some 15 cm perpendicular to bedding into a shale ledge.

Biogenic Structures

Biogenic structures in the Chemung lithofacies of the Gilboa Dam area are of three general types - (1) brachiopod and pelecypod body fossils, (2) ichnofossils and (3) fossil seed-ferns.

Brachiopods and pelecypods occur in both sandstones and shales as isolated specimens and as concentrations that appear to be allochthonous. Those found in allochthonous arrangements were considered, for purposes of this study, as biological sedimentary particles occurring in lithified sediment not necessarily that of their life environments. Ichnofossils in the Chemung lithofacies of the Schoharie Valley occur on bedding planes of sandstone as shallow, generally circular and ovoid depressions, which are slightly darker in color than the enclosing lithology. These occur in two sizes; those only about 1 cm in diameter, and those 2.5 cm or more in diameter. The smaller of the two extend downward perpendicular to bedding a distance of up to some 15 cm. At one locality abundant vertical burrows are 30 cm in length. A few of the burrows have a Y or U pattern.

Fossil seed-fern stumps are present at three stratigraphic levels in the upper Hamilton beds near Gilboa Dam. Over two hundred stumps were taken from the lowest of these levels during quarrying operations just north of the dam (Goldring, 1924, 1927). They occur in light olive-gray (5 GY 6/1), tabular and trough cross-bedded, fine-grained sandstones some of which contain vertical burrows up to 30 cm long. The beds are thick and very thick bedded, are in part slightly calcareous and, at certain levels, contain abundant casts of large spiriferid brachiopods.

ENVIRONMENTAL SYNTHESIS

The spectrum of Tully interval sedimentary environments includes sandstone bodies of alluvial channel origin which truncate underlying beds, contain basal shale-pebble lag-concentrates, are well trough cross-bedded, texturally immature, and display a "fining-upwards". The alluvial strata of overbank origin are horizontally laminated, red and green siltstones. Strata of the marsh facies consist of black organic lenses containing abundant plant remains some of which are "coalified." At the distal margin of the alluvial plain, just below the Tully interval, a swamp environment is represented by three levels of abundant fossil seed-ferns.

Sedimentation that resulted in strata of tidal origin within the Tully interval was of the Wadden-type. The tidal flat facies consists of gray, very finely cross-laminated muddy siltstone and very fine-grained sandstone, which contain allochthonous brachiopods and locally well developed mud-cracks. Sedimentary structures of the tidal channel facies are essentially identical to those of the alluvial channel facies, but can be distinguished by the unique character of the basal lag-concentrate, which is coquinite or coquinoid pebble conglomerate consisting largely of allochthonous brachiopod shells.

Strata of the nearshore facies consist of thick bedded bar sandstone bodies interbedded with very thinly bedded and laminated, fossiliferous siltstone that becomes increasingly calcareous westward and grades into the very argillaceous eastern extension of the Tully Limestone. Well developed trends of change in texture, general biologic character, and type and scale of sedimentary and biologic structures are present in both the nearshore (bar and lagoon) facies and the offshore facies.

Synthesis of the environmental pattern of the Tully interval indicates that (1) Tully sedimentation occurred during the transgressive phase of a transgressive-regressive cycle, (2) terrigenous material was trapped east of a submarine topographic high, thus permitting deposition of carbonate material in a basin that was for the most part being overwhelmed by clastic influx, and (3) landward migration of the strandline during the transgressive phase caused river mouth drowning and resulted in more widespread estuarine (tidal) conditions than were present immediately prior to and following Tully time. In addition, the transgression raised the base level of streams that were flowing westward across the deltaic plain, thus causing alluviation of fine-grained sediment in quantity greater than that deposited directly preceding and following Tully time.

The distribution of the environmental facies of the Tully clastic correlatives is shown on Figure 3.

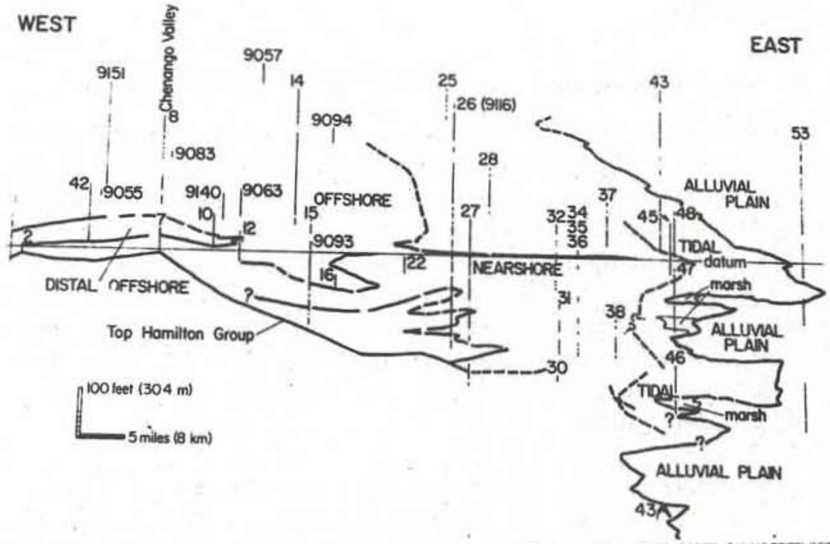

Figure 3 - Cross-section of Tully clastic correlatives. The section extends from East Windham on the northeastern front of the Catskill Mountains northwest to Georgetown in the Otselic Valley. Two-digit stratigraphic section designations are those of Johnson (1968). Four-digit designations are those of Thayer (1972).

BIOGENIC STRUCTURES

Biogenic structures are structures produced by organisms moving or living in or on the sediment. They include trace fossils, which are discrete tracks, trails and burrows. In the last 25 years biogenic structures, particularly trace fossils, have been used as aids in interpreting ancient depositional environments. The application of trace fossils in paleoenvironmental analysis has been based on a theoretical model developed by Seilacher (1964, 1967), in which the distribution of trace fossils, representing animal behavior, is related to factors which change with water depth. In high energy nearshore environments food is suspended in the overlying water rather than deposited in the sand substrate, resulting in a predominance of permanent dwelling burrows of suspension-feeding animals. In more quiet water offshore conditions, potential food particles are included in the fine-grained sediments; here horizontal feeding burrows are more common. Recent workers, including Rhoads (1967), Howard (1972), Frey (1975), and others have emphasized that local energy and substrate conditions and environmental fluctuations are more important than depth in determining the distribution of trace fossils.

The Tully clastic equivalents and related rocks contain moderately diverse and abundant biogenic structures. Trace fossils are found in siltstones, sandstones and limestones of alluvial offshore facies. They occur scattered throughout in low densities, concentrated along sandstone-shale interfaces, and in great abundance in some beds. It is difficult to recognize horizon or thin bed with large numbers of trace fossils, especially horizontal structures, if the exposure is a vertical face. With a few exceptions, trace fossils are seen most completely on bedding planes; good trace localities are therefore those with large exposures of bedding surfaces. Of the outcrops of the Tully equivalents and related rocks, the best outcrops for trace fossils are generally old quarries, where scraped bedding planes and quarried blocks provide large surface areas. Stream exposures are poor, for the few bedding planes exposed are commonly covered with overgrowth; likewise, few bedding surfaces are exposed in road cuts. The diversity of trace fossils from a given facies is, therefore, partly a function of the number of available quarries. In all outcrops, most of the trace fossils were collected from float. For this reason the locations of biogenic structures within the sections are not given precisely.

Because of sampling difficulties imposed by the trace fossil distribution, the type of exposures, and the impossibility of defining what constitutes one specimen of some trace fossils, no quantitative estimates of the abundances of biogenic structures in each facies have been made. However, although some of the biogenic structures, including the small type of <u>Arenicolites</u>, <u>Spirophyton</u>, ? <u>Teichichnus</u> and large vertical burrows are restricted to rocks of the tidal and alluvial or tidal and nearshore facies, most of the others range from alluvial or tidal to offshore facies or from proximal nearshore to distal offshore. In addition, many of the biogenic structures are found in diverse rock types - siltstones, sandstones, and limestones. This indicates that in the Tully clastic correlatives the distribution of the trace fossils is not related clearly to the inferred depositional environments.

Descriptions of trace fossils

Ten major types of trace fossils occur in the Tully clastic correlatives, and there are probably many more kinds of less common or less readily identifiable biogenic structures in the unit. In the descriptions below, trace fossils which have been given formal ichnogeneric names are discussed in alphabetical order, followed by the types which have not been given formal names.

Arenicolites: (Plate 1H, 2B, F). Specimens of Arenicolites are vertically oriented U-shaped burrows without spreiten. (A spreite is a layer of U-in U-shaped lamellae. It may have any orientation within the rock.) Two types of Arenicolites occur in the Tully clastic correlatives: 1) long, narrow burrows with fill darker than the surrounding rock, (Plate 2F) and 2) larger specimens with burrow fill similar to that of the surrounding rock (Plate 1H, 2B). Arenicolites is thought to be produced by a polychaete worm (Hantzschel, 1975; Janssa, 1974). The small type closely resembles burrows produced by spionid (polychaete) worms in uppermost intertidal zones in southern Californian lagoons. Although generally restricted to shallow water, high energy environments (Crimes, 1975), Janssa (1974). The small type closely resembles burrows produced by spionid (polychaete) worms in uppermost intertidal zones in southern Californian lagoons. Although generally restricted to shallow water, high energy environments (Crimes, 1975), Janssa (1974) reported Arenicolites from deeper water deposits. In the Tully clastic correlatives, the small type of Arenicolites is restricted to sandstones of the tidal and nearshore facies. The larger type occurs, but is rare, in rocks deposited under tidal and offshore conditions.

Bifungites: (Plate 1G). Appearing as a dumbbell-shaped structure on a bedding plane, Bifungites is interpreted as the cross-section of a spreite-bearing, vertically oriented U-shaped burrow (Osgood, 1970). Commonly considered to be a shallow-water structure, in the Tully equivalents it occurs in rocks of the tidal, nearshore, and offshore facies but is nowhere common. Like Arenicolites, it probably represents the dwelling burrow of a worm-like animal.

? Phycodes: (Plate 1E). Vertical sections of sandstones and siltstones of the nearshore and offshore facies show clusters of small (1 mm or less in diameter) horizontal burrows filled with lighter material than the surrounding rock. These are tentatively identified as Phycodes and probably are feeding burrows. Many modern deposit-feeding polychaete worms are very long and narrow and might produce similar burrows.

Planolites: (Plate 1C, D, F). Unbranched horizontally oriented burrows are included in the ichnogenus Planolites, if the burrow fill differs from the surrounding rock (see Osgood, 1970; Alpert, 1975 for discussion). Many of the Tully equivalents specimens are surrounded by a dark burrow lining (Plate 1C). If specimens are not oriented and sectioned, it is difficult to distinguish Planolites from the molds of trails made as surficial grooves. Planolites is one of the most abundant trace fossils in the Tully equivalents. A small type (less than 0.5 cm in diameter) is especially common (Plate 1F), although the larger form (larger than 0.5 cm in diameter) can be found at many outcrops (Plate 1C, D). Planolites is classified as a feeding burrow (Seilacher, 1964); the animal is thought to have ingested sediment and filled its burrow with the undigestible remains. In the Tully clastic correlatives and associated rocks, Planolites ranges from the tidal to offshore facies. This concurs with its designation as a facies-crossing trace fossil (Seilacher, 1967).

Skolithos: (Plate 1I, 2D). Vertical cylindrical burrows which may or may not be closely packed are included in the ichnogenus Skolithos. Two types of Skolithos occur in the Tully clastic correlatives: 1) a large type, greater 0.5 cm in diameter, which occurs in rocks of the alluvial to offshore facies, but is most common in sandstones of the nearshore facies (especially section 36) and 2) a smaller form, less than 5 mm in diameter which occurs in sandstones, and siltstones of all of the facies (Plate 1I, 2D). The small type of Skolithos is the most common trace fossil in the Tully clastic correlatives. Skolithos is interpreted as the dwelling burrow of a suspension feeding animal (Alpert, 1975). It is common in sandstones deposited under high-energy tidal and nearshore conditions (Seilacher, 1967; Crimes, 1975).

Spirophyton: (Plate 2A). Simpson (1970) defined Spirophyton as consisting of a central vertical tube around which a speite is spirally wound and only differing from Zoophycos in its smaller size. In the Tully equivalents Spirophyton occurs as circular areas (horizontal layers of the spreite) on bedding planes surrounding a central tube (Plate 2A). Seilacher (1964) designated the similar Zoophycos as indicative of middle depth deposition, but it has been found in shallower water deposits (Osgood and Szmuc, 1972; Kern and Warme, 1974; Thayer, 1974). In the Tully equivalents, however, Spirophyton is restricted to siltstones of the tidal and alluvial facies; it is abundant in some horizons in the tidal facies. Simpson (1970) interpreted Spirophyton and Zoophycos as resulting from the feeding activity of a bilaterally symmetrical animal. Other interpretations of the ichnogenera as plants (Loring and Wang, 1971) or body fossils (Plicka, 1970) are not widely accepted.

? Teichichnus: Generally horizontal burrows with vertically oriented spreiten extending above or below the burrows are included in Teichichnus. Because specimens in the Tully equivalents and related rock are more curved than most, they are only tentatively assigned to that ichnogenus. Well preserved specimens of ? Teichichnus were found in sandstones of the tidal facies; questionable specimens were found in sandstones of the offshore facies. Teichichnus is generally found in rocks deposited under more offshore conditions (Crimes, 1975) and is interpreted as the feeding burrow of a deposit feeding animal.

Zoophycos: (Plate 1J, 2C). Zoophycos is similar to Spirophyton but larger in diameter (Simpson, 1970). In the Tully equivalents, only the expressions of the spreiten on bedding planes have been recognized; these are lobate to nearly circular in outline (Plate 2C). On polished vertical surfaces chevron shaped lamellae within the spreiten are visible (Plate 1J). Zoophycos is rarely found in place, as it is difficult to recognize on vertical weathered surfaces. Where it is found in place it may cover a bed a foot or more thick. Generally, however, Zoophycos is not as abundant in the Tully clastic correlatives as it is in the Schoharie Formation in the Hudson Valley or Carlisle Center Formation, especially near Cherry Valley. Zoophycos occurs in siltstones, sandstones and limestones of the nearshore and offshore facies. This and other occurrences in New York State (Thayer, 1974; Marintsch and Finks, 1976; Rehmer, 1977) are additional evidence that the producers of Zoophycos were not restricted to bathyal depths.

Arthropod produced trails and trackways: (Plate 1K). A variety of arthropod produced lebensspurren occur - but are not abundant in - siltstones and sandstones of tidal to offshore facies of the Tully clastic correlatives and associated rocks. These are of diverse morphology and include resting tracks (Rusophycus), trilobite-crawling tracks (Cruziana), and smaller trackways (Isopodichnus) (Plate 1K). All, however, are bilobed and show transverse markings interpreted as scratch marks. Isopodichnus has been considered to be restricted to be restricted to nonmarine rocks (Trewin, 1976). The distinction between it and Cruziana is arbitrarily (Hantzschel, 1975) based on width of the trail.

Large vertical burrows: (Plate 2G). Very large (greater than 5 cm in diameter) vertical burrows with or without burrow linings are found in the sandstones of the tidal and nearshore facies (Plate 2G). Modern cerianthids (coelenterates) produce large deep vertical burrows, and actinians (anemones) capable of producing burrows of that size are infaunal inhabitants of modern nearshore sediments. These probably are, therefore, the dwelling burrows of suspension feeding animals.

Large horizontal traces: Although not abundant, very large (greater than 2 cm in diameter) horizontal burrows occur in fine sandstones of the nearshore and offshore facies (Plate 2E). Some of these may be molds of surficial trails, but several were probably produced intrastratally. Possible producers include burrowing trilobites or soft bodied deposit-feeding animals such as holothurians.

Surface trails: (Plate 1A, B). Some specimens are indistinguishable from Planolites on bedding surfaces are clearly molds of surficial trails, for on polished vertical sections laminations extend into the trace (Plate 1B). These are common and widespread in the Tully clastic equivalents, occurring in siltstones and sandstones of the alluvial to offshore facies.

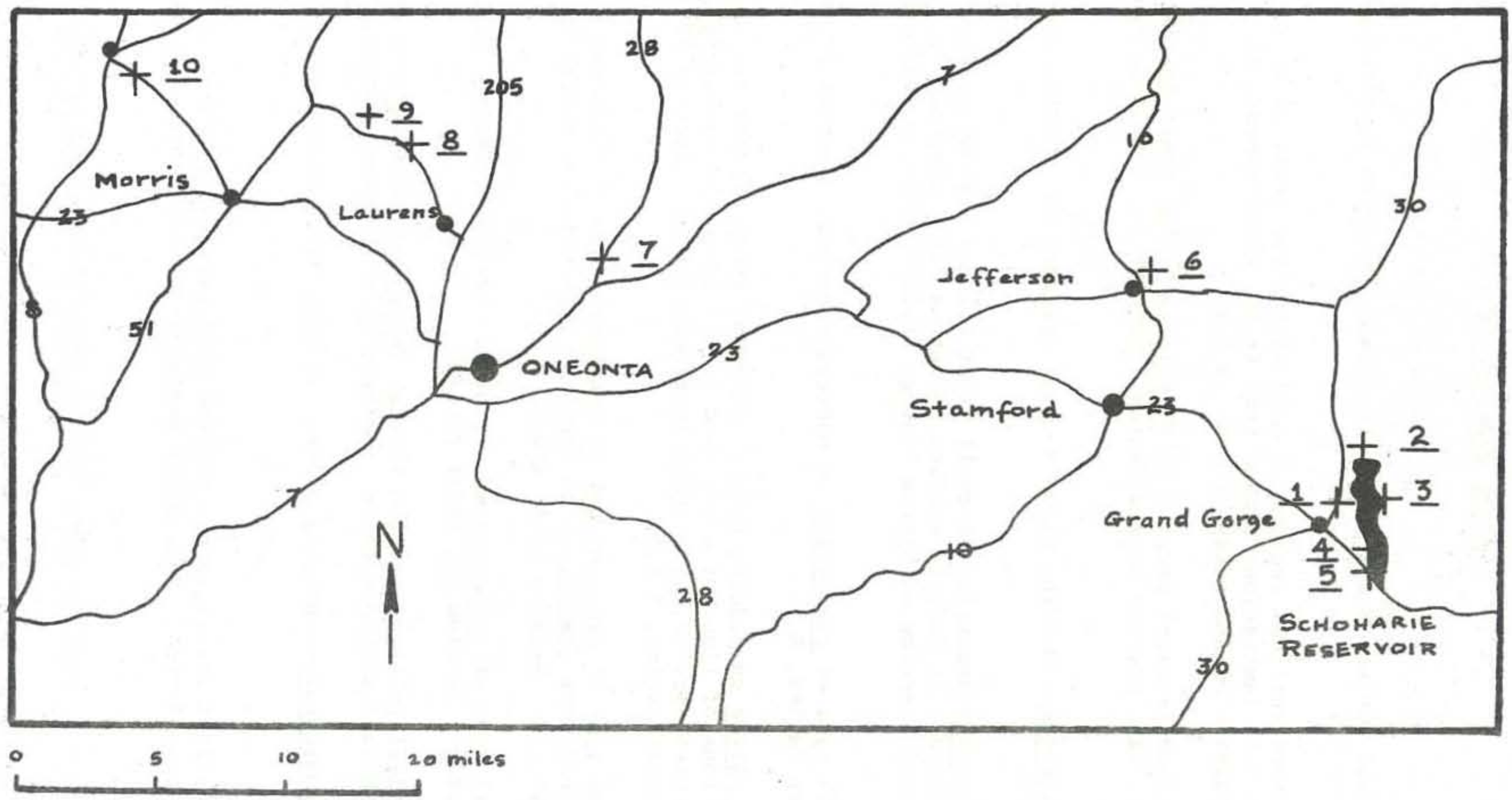

Figure 4. Locations of Field Trip Stops

PLATE EXPLANATION *

Plate 1

A. Mold of surface trail on bedding plane. Section 1, offshore facies X 1.

B. Polished vertical section of mold of surface trail shown in A. Note that laminations extend into trace, which appears as depression on underside of bed. X 1.3.

C. Polished vertical section of Planolites (large type) showing dark, fine grained burrow lining. Section 27, nearshore facies, X 1.

D. Planolites. Bedding plane view of specimen in C before sectioning. X 0.7.

E. ? Phycodes appearing as small light colored burrows occurring in clusters. At left is section through a large specimen of Skolithos, showing layering of burrow lining. Section 9057, offshore facies, X 1.

F. Small type of Planolites on underside of bed. Section 27, nearshore facies, X 1.

G. Bifungites on bedding plane. Enlarged areas at ends are cross-sections of limbs of a U-shaped burrow connected by vertically oriented spreite, also shown in cross-section. Section 9094, offshore facies, X 1.5.

H. Large type of Arenicolites in weathered face of sandstone of tidal facies; note similarity to specimen from offshore facies in Plate 2 B. Section 43 A, X 0.5.

I. Small type of Skolithos in weathered vertical section. Disc is a quarter. Section 43, tidal facies.

J. Vertical polished section through Zoophycos, showing dark chevrons (lamellae) within spreite. Gilbert Lake, offshore facies, X 1.3.

K. Isopodichnus on bedding plane. Section 9063, offshore facies, X 2.

* Two-digit stratigraphic section designations are those of Johnson (1968). Four-digit designations are those of Thayer (1972).

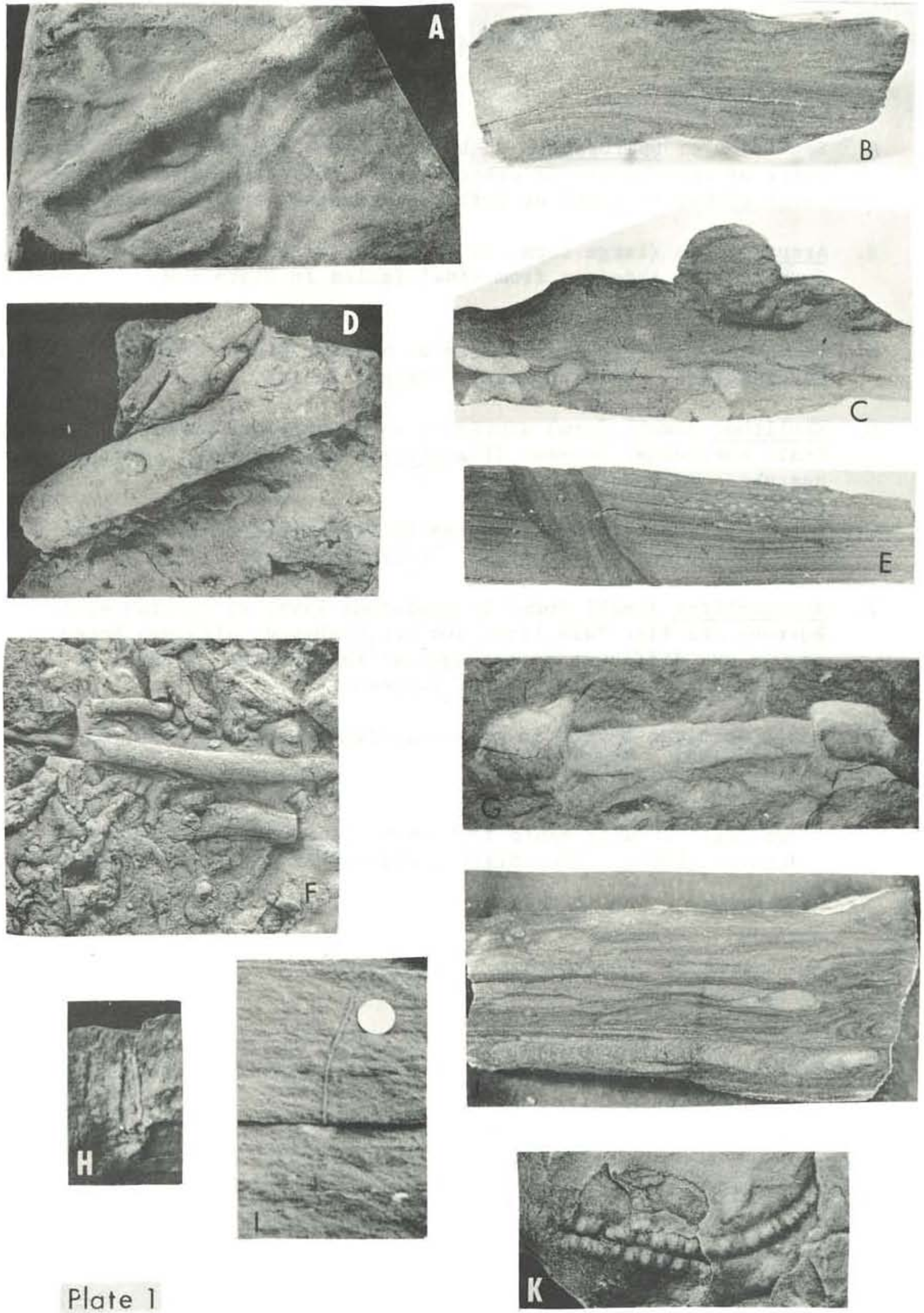

Plate 1

PLATE EXPLANATION*

Plate 2

A. Specimens of Spirophyton on bedding plane. Each specimen is one swirl of spreite around central tube. Lamellae within spreite swirl either to right or left. Section 47, tidal facies, X 0.5.

B. Arenicolites (large form) in sandstone of offshore facies. Compare with specimen from tidal facies in Plate 1 H. Gilbert Lake, X 1.

C. Zoophycos. Portion of spreite on bedding plane. Vertical burrows cut lamellae. Gilbert Lake, offshore facies, X 1.

D. Skolithos (small form) expressed as depressions on bedding plane. Small horizontal burrows (Planolites) also present. Section 27, nearshore facies, X 1.

E. Large horizontal traces on slab in stream bed at section 15. Lens cap in center for scale. Offshore facies.

F. Arenicolites (small form) in sandstone layer at section 43-A. Burrows are fine dark lines and are U-shaped, although bases of U's are difficult to see even at the outcrop. Pencil at upper right for scale. Tidal facies.

G. Large vertical burrow in cross-section on bedding plane at section 43-A. Tidal facies.

*Two-digit stratigraphic section designations are those of Johnson (1968). Four-digit designations are those of Thayer (1972).

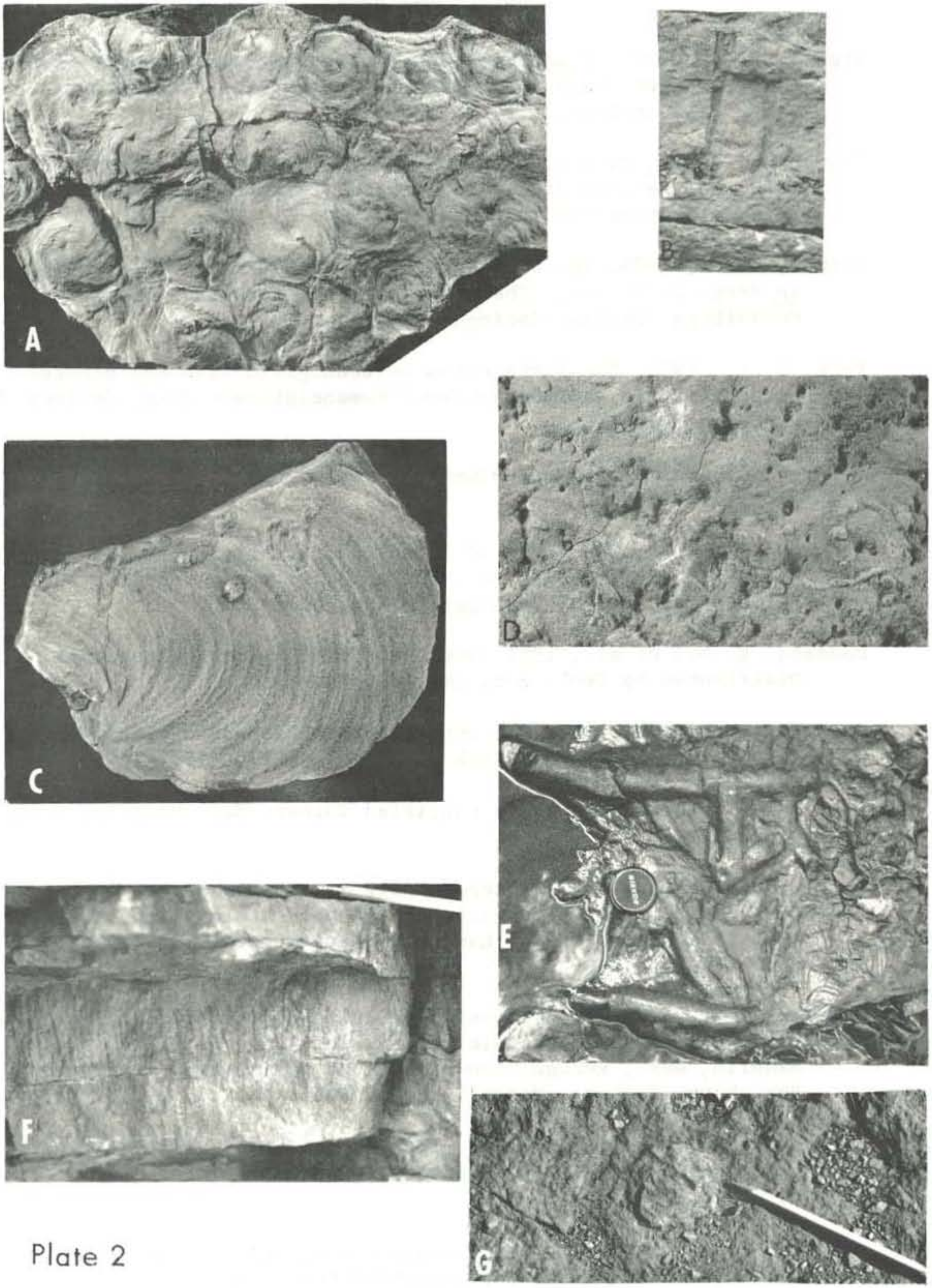

Plate 2

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TRIP A-2

Ichnofossils of the Tully Clastic
Correlatives in Eastern New York State

ROAD LOG

Miles Between Points	Total Miles	Descriptions and Directions
0	0	LEAVE SUCO Campus. Turn left on West Street. Proceed down hill.
		ON RIGHT - HARTWICK COLLEGE.
0.6	0.6	Stop light. TURN LEFT onto Rts. 7 and 23 (Chestnut Street).
0.3	0.9	Stop light on Main Street. TURN RIGHT on Rts. 23 and 28.
		Cross SUSQUEHANNA RIVER.
0.6	1.5	BEAR LEFT. Proceed east on Rt. 23.
1.0	2.5	ON LEFT - Susquehanna River.
0.8	3.3	ON RIGHT - Holiday Inn.
0.1	3.4	ON LEFT - Notice flat-topped crest of hills. Streams are eroding into horizontally bedded rocks of Catskill lithofacies.
1.8	5.2	ON LEFT - VW dealer.
1.4	6.6	On left - road to WEST DAVENPORT.
1.1	8.7	Enter DAVENPORT CENTER.
4.2	12.9	Enter DAVENPORT.
1.5	14.4	BUTTS CORNERS.
6.3	20.7	ON RIGHT - Kame and kettle topography.
4.9	25.6	Enter VILLAGE OF STAMFORD
0.2	25.8	Intersection Rts. 23 and 10. CONTINUE EAST ON RT. 23.
4.7	30.5	Enter Delaware County.

Miles Between Points	Total Miles	Descriptions and Directions
2.8	33.3	Enter GRAND GORGE.
0.5	33.8	Intersection Rts. 23 and 30. TURN LEFT (North) onto Rt. 30.
1.0	34.8	Enter Schoharie County.
0.5	35.3	ON RIGHT - Top of Grand Gorge Section 43 of Johnson, 1968). Exposure consists of alluvial channel sandstone resting on red overbank shale.
		PROCEED DOWN HILL
0.4	35.7	Top of tidal channel facies.
		CONTINUE TO BOTTOM OF HILL
0.2	35.9	PARK on right side of road. Walk back to tidal channel outcrops. BE VERY CAREFUL. THIS IS A NARROW SPEEDWAY WITH POOR VISIBILITY.

STOP 1 (Gilboa & Prattsville 7½' Quads.) Outcrop is cross-bedded sandstone of tidal channel facies with lag-concentrates of shallow marine spiriferid brachiopods.
Ichnofossils:
2nd exposure above base (begins approximately 50 feet above base of section): Intermediate-sized (3-5 mm) specimens of Skolithos, large vertical cylindrical structures (rare, near top) molds of surface trails on undersides of beds.

3rd exposure above base: some Skolithos; also nondescript bioturbation, but this difficult to determine because of poor definition of lamination.

Upper section: abundant medium and small sized specimens Skolithos in siltstone float; Planolites also common. Well preserved specimens of Spirophyton are rare, but incomplete specimens are fairly common. Much of rock is highly bioturbated.

Miles Between Points	Total Miles	Descriptions and Directions
		CONTINUE NORTH ON RT. 30
0.1	36.0	ON RIGHT, in distance - Large quarry from which much of stone for Gilboa Dam was taken. Completion of dam impounded waters of Schoharie Creek, forming Schoharie Reservoir; a part of New York City water supply system.
0.6	36.6	TURN RIGHT on road to GILBOA.
0.5	37.1	AHEAD - View north down Schoharie Valley.
0.6	37.7	GILBOA. On right - display of seed-fern stumps taken from quarry just to southwest. Some 200 specimens were found during the quarrying operation. These seed-ferns are thought to have grown to heights of some 60 feet in swamps along the seaward margin of the Catskill deltaic plain during late Medial Devonian time. They were buried during a minor oscillation of the marine shoreline in tidal channel or bar sand deposits. DO NOT CROSS BRIDGE. TURN LEFT (NORTH) ONTO STRYKER ROAD (County Rt. 13).
		PROCEED NORTH ALONG SCHOHARIE CREEK.
1.3	39.0	PARK ON RIGHT <u>STOP 2</u> (Gilboa 7½ Quad.)- Ledges on west bank of Schoharie Creek consisting of burrowed Hamilton Group sandstones. <u>Ichnofossils</u>: Lower part of section: Underneath re-entrant are specimens of <u>Planolites</u>, <u>Isopodichnus</u>; small paired burrows of <u>Arenicolites</u> can also be seen. Larger U-shaped burrows (<u>Arenicolites</u>) and <u>Skolithos</u> occur in overlying bed. Under a re-entrant on the upstream side of the outcrop is ? <u>Teichichnus</u>; other specimens occur at about this layer. Upper bedding surfaces: 2 sizes <u>Skolithos</u>; sediment scoured from around larger burrows. Larger vertical burrows are common; horizontal burrows (<u>Planolites</u>) less so. Specimens of <u>Arenicolites</u> and <u>Isopodichnus</u> are rare.

Miles Between Points	Total Miles	Descriptions and Directions
		TURN AROUND. RETURN TO GILBOA BRIDGE.
1.3	40.3	GILBOA BRIDGE. TURN LEFT (EAST) AND CROSS BRIDGE.
		CLIMB HILL. STAY ON SURFACED ROAD.
0.5	40.8	ON RIGHT - Gilboa Dam.
0.3	41.1	ON LEFT - Gilboa Central School
0.9	42.0	ROAD FORKS. TAKE RIGHT FORK TOWARDS PRATTSVILLE. CROSS MANORKILL BRIDGE.
0.1	42.1	PARK ON RIGHT (at south end of bridge). Walk down path to mouth of Manor Kill. STOP 3 (Gilboa 7½' Quad., Section 46 of Johnson, 1968). The beds exposed in the Manor Kill Gorge are within the upper part of the Hamilton Group. Those in the lower part of the section, adjacent to the Schoharie Reservoir, are trough cross-bedded, burrowed, medium-grained sandstone of the Chemung lithofacies assigned to the tidal channel facies. Some of these sandstones are rich in plant material and in a few places, during low water stages of the reservoir, fossil seed-fern stumps, in growth position, may be seen. The remainder of the section upstream consists of interbedded red and green shales, dark gray shales and medium gray, shallowly cross-bedded, fine-grained sandstone; interpreted, respectively, as distal alluvial plain, tidal flat and tidal channel facies. Ichnofossils: Base (below spring water level): Ripple marked bed covered with small specimens of Skolithos, abundant Planolites and Skolithos in float.
		(just above spring water level): Arenicolites, Skolithos, Planolites, Bifungites (rare) and Cruziana in blocks of float at water level.
		TURN AROUND. RETURN TO GILBOA BRIDGE, THEN TO RT. 30.

Miles Between Points	Total Miles	Descriptions and Directions
3.0	45.1	TURN LEFT (South) ONTO RT. 30.
0.5	45.6	TURN LEFT ONTO "ROAD SEVEN" (unsurfaced). Proceed south along west side of Schoharie Reservoir.
3.2	48.8	ON LEFT - Road to Intake Building of Schoharie Reservoir. PARK ON RIGHT. WALK DOWN ROAD to Intake Building STOP 4 (Gilboa 7½' Quad., Section 47 of Johnson, 1968). The lower 17' of section consists of dark gray siltstone and shale; above this is 114' of lighter gray, in part shallowly cross-bedded, fine-grained sandstone of tidal or very shallow sub-tidal origin. Ichnofossils: Base: Abundant specimens of Spirophyton in ditch outcrop behind Intake Building; also some fine sandstone above this is highly bioturbated. About 50' above base (at level of birch post): Cruziana (?) on underside of sandstone bed. Middle: few layers with molds of surface trails exposed on undersides of beds up hill from road. CONTINUE SOUTH ON "ROAD SEVEN".
1.0	49.8	PARK ON LEFT BEFORE CROSSING BRIDGE. STOP 5 (Prattsville 7½' Quad., Section 48 of Johnson, 1968) - At this point Bear Kill drops over Hardenburg Falls and flows into Schoharie Reservoir. Beds here are assigned to the tidal channel and tidal flat facies. The tidal channel facies is represented by gray, cross-bedded, fossiliferous sandstones and the tidal flat facies by very dark gray, very thin-bedded, in part conglomeratic, shales. Lag-concentrates in both facies are rich in shallow marine brachiopod shells. Ichnofossils: Base: Rare Skolithos and Planolites; very rare large cylindrical burrows.

Miles Between Points	Total Miles	Descriptions and Directions
		About 8' above base: Skolithos
		Above falls: thin bedded siltstone with rare Planolites.
		CROSS BRIDGE AND CONTINUE TO RT. 23
0.3	50.1	TURN RIGHT (WEST) ONTO RT. 23.
2.4	52.5	ENTER GRAND GORGE.
0.5	53.0	JUNCTION RTS. 23 & 30. CONTINUE WEST ON RT. 23.
6.9	59.9	ENTER VILLAGE OF STAMFORD.
1.0	60.9	JUNCTION RTS. 23 & 10. TURN RIGHT (NORTH) ONTO RT. 10.
1.0	61.9	ON LEFT - Department of Environmental Conservation Regional Headquarters.
1.9	63.8	ON LEFT - Outcrop of Catskill lithofacies.
4.0	67.8	ENTER JEFFERSON
	68.1	STOP SIGN. TURN RIGHT AND CONTINUE NORTH ON RT. 10.
		TURN RIGHT ON UNSURFACED ROAD.
		ON LEFT - Small house on left just below prominent sandstone ledge. STOP 6 (Summit 7½' Quad., Section 36 of Johnson, 1968) - In roadside quarry, about 0.2 mile east of house, shales of offshore facies. Behind house are sandstones of probable bar origin.
		Ichnofossils: Lower quarry: Several layers with interference ripple marks cut by Skolithos and Planolites with coarser burrow fill.

Miles Between Points	Total Miles	Descriptions and Directions
		Section behind house: Abundant large *Skolithos*. Note that a few burrows intersect. Some of the burrow walls are clearly defined, others not. A few layers contain small sinuous specimens of *Planolites* as well. A poorly preserved specimen of *Cruziana* has also been found here. Burrows formed in the relatively coarse sand would have been more likely to collapse than those formed in more fine grained sediments.
		TURN AROUND. RETURN TO RT. 10.
4.3	72.4	TURN LEFT (SOUTH) ON RT. 10.
1.0	73.4	IN JEFFERSON, TURN RIGHT (WEST) ONTO "MAIN STREET".
0.6	74.0	Leave JEFFERSON.
3.4	77.4	Enter NORTH HARPERSFIELD.
4.5	81.9	TURN RIGHT (WEST) ONTO RT. 23.
4.2	86.1	Enter DAVENPORT
4.3	90.4	Enter DAVENPORT CENTER.
2.8	93.2	TURN RIGHT ONTO DELAWARE COUNTY RT. 11 TO WEST DAVENPORT.
0.5	93.7	Stop Sign. TURN LEFT.
2.4	96.1	Cross SUSQUEHANNA RIVER.
0.3	96.4	Cross over Rt. I-88.
0.2	96.6	JUNCTION WITH RT. 7 & 28. TURN RIGHT (NORTH-EAST) ONTO RT. 7 & 28.
2.1	98.7	Enter COLLIERSVILLE.
0.3	99.0	Rts. 7 & 28 Separate - TURN LEFT (NORTH) ON RT. 28 TOWARDS COOPERSTOWN.
0.9	99.9	PARK ON RIGHT SHOULDER AT Goodyear Lake Dam. ON LEFT EXTENSIVE OUTCROP.

Miles Between Points	Total Miles	Descriptions and Directions
		STOP 7 (Milford $7\frac{1}{2}$' Quad., Section 22 of Johnson, 1968) - This outcrop contains an example of the flow-rolls which are locally common in the Chemung lithofacies. These occur as beds of internally disturbed structure underlain and overlain by horizontal, well-bedded strata. Within the flow-roll beds are nodule-shaped, concentrically laminated masses of medium gray, very fine-grained sandstone enclosed in slightly darker colored siltstone. The laminar structure is due to concentric, extremely thin, dark laminae composed largely of very fine plant fragments. The enclosing siltstone commonly has a diapiric relationship to adjacent pillows. This outcrop is at the distal edge of the near-shore facies. Ichnofossils: Base: Specimens of Skolithos and Planolites are present, but not common. They are most easily seen on shale partings. Note the absence of trace fossils near the flow structures. About 10 feet above flow structures: Specimens of Skolithos and Planolites and molds of surface trails rare to common on shale partings. TURN AROUND AND RETURN TO I-88 VIA RT. 7 & 28.
0.8	100.7	RT. 7 & 28. TURN RIGHT (SOUTHWEST).
2.1	102.8	Enter EMMONS.
0.3	103.1	Stop light near drive-in movie. TURN LEFT AND ALMOST IMMEDIATELY TURN RIGHT (WEST) ONTO RT. I-88.
2.0	105.1	Exit for Oneonta Colleges and State Police. CONTINUE WEST ON I-88.
2.8	107.9	Exit for Rt. 205 and MORRIS. TURN NORTH ONTO RT. 205.
1.6	109.5	JUNCTION RTS. 205 and 23. CONTINUE ON RT. 205 & 23.
0.6	110.1	Caution light. Rt. 23 swings left (west). CONTINUE STRAIGHT AHEAD ON RT. 205.

Miles Between Points	Total Miles	Descriptions and Directions
4.0	114.1	ON RIGHT - Road to Oneonta Airport.
0.6	114.7	TURN LEFT onto road to LAURENS.
0.2	114.9	Enter LAURENS.
0.2	115.0	Stop Sign - TURN LEFT.
		CONTINUE THROUGH LAURENS.
0.4	115.4	TURN RIGHT onto Gilbert Lake Road.
1.1	116.5	Fork in road. TAKE RIGHT FORK.
2.4	118.9	ON RIGHT - Entrance to Gilbert Lake State Park.
0.5	119.4	PARK ON RIGHT. WALK UP SERVICE ROAD TO ROCK QUARRY. STOP 8 (Morris 7½' Quad., Section 9094 of Thayer, 1972) - Although well above the Tully clastic correlatives, these fossiliferous, interbedded gray sandstones and shales exhibit typical characteristics of the eastern New York Chemung lithofacies. Ichnofossils: Near base: Abundant specimens *Zoophycos* with diverse forms. It is recognizable in vertical section as a series of horizontally oriented chevrons. Specimens of *Planolites* and *Skolithos* are abundant; *Cruziana*, *Bifungites*, large horizontal burrows and *Arenicolites* are rare, but present. Note specimen of *Arenicolites* on vertical surface of piece of float about seven feet above quarry base. Upper portion of quarry: Abundant specimens of *Planolites*, *Skolithos* and some of *Zoophycos*. Highly bioturbated sandstone is interbedded with laminated sandstone, implying influxes of sediment. CONTINUE TOWARDS NEW LISBON.
2.9	122.3	Four corners (NEW LISBON). TURN RIGHT (NORTH) ONTO OTSEGO COUNTY RT. 14.

Miles Between Points	Total Miles	Descriptions and Directions
0.9	123.2	ON RIGHT - Unsurfaced road. ON LEFT - house and barn. PARK ON SHOULDER AND WALK UP unsurfaced road to roadside quarry. STOP 9 (Morris 7½' Quad., Section 15 of Johnson, 1968) - Beds exposed in this unnamed tributary of Stony Creek and adjacent abandoned quarry are assigned to the offshore facies of the Tully clastic correlatives. Ichnofossils: Base: Planolites - rare to common; Skolithos common to abundant in siltstone; Bifungites rare. Zoophycos absent. In stream bed: Abundant float (fine to very fine sandstone) with abundant Zoophycos. Note diversity of shapes - from nearly elliptical to strongly lobate. Specimens Planolites and Skolithos are also common, as large horizontal burrows. Zoophycos rarely occurs on same slab with other trace fossils. TURN AROUND. RETURN TO FOUR CORNERS.
1.0	124.2	Four corners. TURN RIGHT (WEST) ONTO OTSEGO COUNTY RT. 12.
0.6	124.8	RT. 51. TURN LEFT (SOUTH) TOWARDS MORRIS.
3.8	128.6	Stop light in center of town. Bank on left and Morris Inn on right constructed of Chemung lithofacies flagstone. TURN RIGHT ON N. BROAD ST.
2.4	131.0	ON LEFT - quarry in Chemung lithofacies.
3.7	134.7	ON LEFT - Small quarry directly adjacent to highway. PARK ON RIGHT. STOP 10 (New Berlin South 7½' Quad., Section 9063 of Thayer, 1972). The shale beds in this quarry and in one directly above it are representative of the offshore facies. Ichnofossils: Base: In lower quarry thinly bedded siltstone has abundant specimens of Skolithos and Planolites. Isopodichnus is present, but rare. Sandstone in float is packed with specimens of Zoophycos. Note that central tube extends

Miles Between Points	Total Miles	Descriptions and Directions
		upward (or downward) from bedding plane and that spreiten extend laterally from this tube. This layer is exposed at the intersection of the quarry road and main road.
		Upper quarry: Abundant Skolithos, Planolites; rare Bifungites, Arenicolites and possibly ? Teichichnus. Zoophycos common on some surfaces. Note abundant ripple marks.
		TURN AROUND AND RETURN TO CENTER OF MORRIS.
5.8	140.5	Stoplight at Center of MORRIS. GO STRAIGHT AHEAD ON RT. 23.
9.1	149.6	Enter WEST ONEONTA
0.3	150.9	Junction Rts. 23 and 205.
0.7	151.6	Stop light. TURN LEFT. CONTINUE ON RT. 23.
0.3	151.9	Junction Rts. 23 & 7. CONTINUE STRAIGHT AHEAD.
0.4	152.3	Enter ONEONTA.
1.2	153.5	Stoplight. TURN LEFT ONTO WEST STREET.
		CLIMB HILL.
0.6	154.1	TURN RIGHT ONTO SUCO CAMPUS (Ravine Parkway).

END ROAD LOG