# FRESHWATER CARBONATE FROM THE UPPER DEVONIAN CATSKILL MAGNAFACIES, DAVENPORT CENTER, CENTRAL NEW YORK

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## ABSTRACT

Non-soil carbonates are rare in fluvial deposits of the Upper Devonian Catskill Magnafacies although they are common in other fluvial rocks. A 0.5 m thick dolomitic mudstone bed occurs near the base of the Oneonta Formation at Davenport Center, NY. This laminated mudstone layer contains filament molds, rare ostracode shells, calcispheres and a variety of burrows and mudcracks. Associated strata include sandstones interpreted as channel deposits and interbedded sandstones and mudstones interpreted as crevasse-splay, levee and flood basin deposits. We interpret the carbonate bed as a freshwater-marsh/shallow-lake deposit analogous to the "periphyton" lakes and marshes of the Everglades and interior Andros Island. This marsh/lake deposit developed during local reduction of siliciclastic input. The purpose of this trip is to examine the carbonate bed and associated strata, to compare the sequence with similar coeval sequences in the region, and to discuss our interpretations.

## INTRODUCTION

Carbonates are common in many modern and ancient fluvial deposits where they occur both as early diagenetic soil features and as the deposits of a variety of freshwater lakes and swamps. Descriptions of freshwater, non-pedogenic carbonates from ancient alluvial deposits include: Beerbower (1961), Belt and others (1967), Belt (1968), Friend and Moody-Stuart (1970), Berryhill and others (1971), Freytet (1973), Leeder (1974), Ryder and others (1976), Beaumont (1979), Ferm and Horne (1979), Flores (1981), Ordonez and Garcia del Cura (1983), and Anderton (1985). However, only a limited number of thin (< 0.5 m) non-pedogenic carbonate mudstone beds are known from the fluvial part of the Devonian clastic wedge in central New York (Johnson and Friedman 1969, p 461; Demicco and others 1987; Bridge and Willis 1991). Most of these are found in cores drilled by New York State Power Authority in the vicinity of Gilboa, New York, but a few can be found in outcrops of siliciclastic mudstones deposited near the paleoshoreline (Bridge and Willis 1991).

The carbonate mudstone that is the subject of this trip is the exception in that it is apparently associated with wholly non-marine rocks (Demicco and others 1987). It is also the thickest (approximately 0.5 m thick) and best exposed carbonate in the area. The carbonate bed occurs in an abandoned quarry about 1 km south of Davenport Center in south-central New York (Fig. 1). We reckon the quarry is near the base of the Frasnian Oneonta Formation (Fig. 2), but the precise stratigraphic position of this quarry is hard to define because of the scale of geologic maps of this region (Fisher and others 1970) and because the rock types exposed are not unique to the Oneonta Formation. The purposes of this trip are to: (1) describe the sedimentary features of the carbonate bed and associated strata; (2) present our interpretations of the depositional environments; and (3) discuss the implications of the carbonate bed for sedimentation rates and paleoclimate.

## DESCRIPTION AND INTERPRETATION OF ASSOCIATED STRATA

The quarry wall is about 130 m long, 20 m high and oriented east-west. Figure 3 is a vertical measured section from the thickest central portion of the quarry. The section comprises a basal 4 meter thick sandstone and an upper 13 m or so of interbedded sandstone and mudstone.

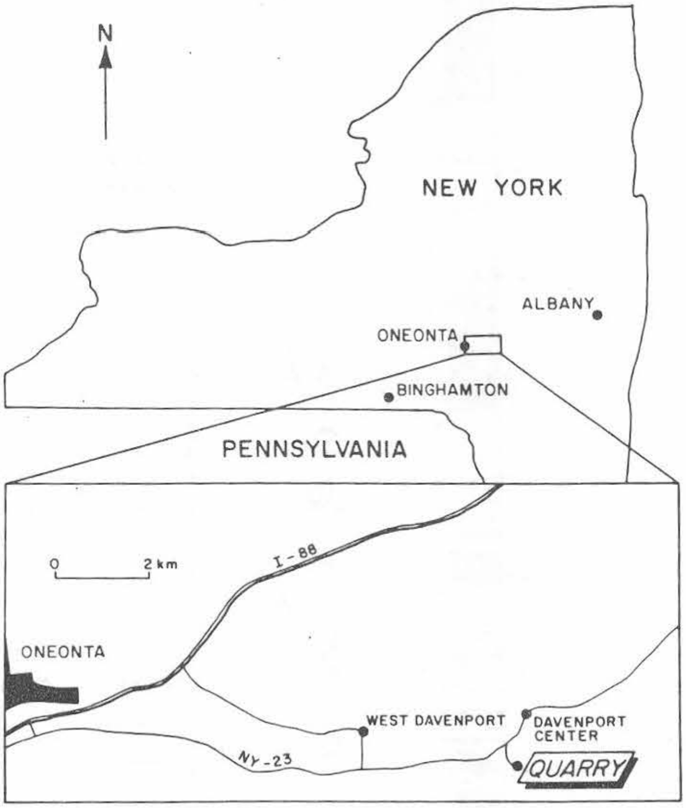


Figure 1. Location Map.

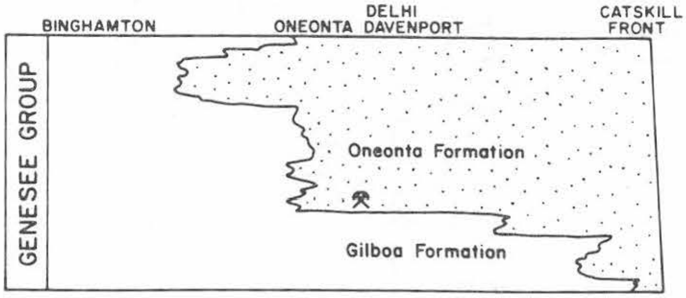


Figure 2. Stratigraphic chart (from Rickard 1975). Quarry marked by symbol. Catskill Magnafacies (alluvial) is stippled. Genesee Group is about 450 m thick in this region (Rickard 1975).

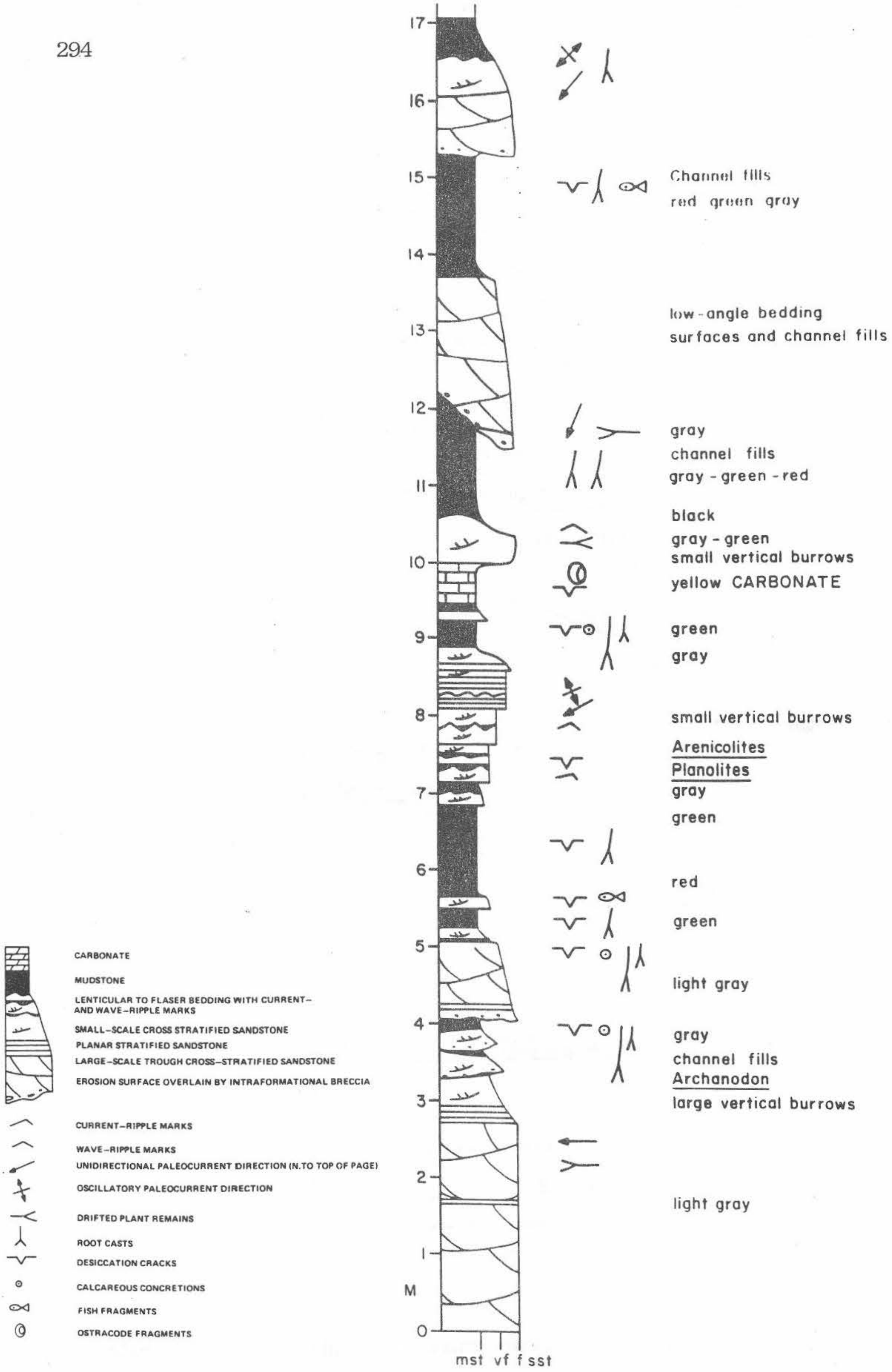


Figure 3. Measured section from the central portion of the quarry. Scale is height above quarry floor in meters. Refer to explanation of symbols. Other sedimentary features noted to right of graphic log.

***Description of the basal sandstone:*** The basal 3 m of the quarry is composed of gray, fine-grained, large-scale cross-stratified sandstone that grades up to very fine-grained, planar-stratified and small-scale cross-stratified sandstone in the uppermost 0.5 m. Overlying this are decimeter-thick bedsets which fine upward from small-scale cross-stratified very fine-grained sandstone to gray mudstone. These bedsets fill meters-wide channels and contain mudcracks, root casts, calcareous concretions, large vertical burrows, and rare impressions of shells of the bivalve *Archanodon*.

***Interpretation of the basal sandstone:*** The thick sandstone at the base of the section is interpreted as a major channel deposit, with the overlying minor channel fills representing chute-channel or crevasse-channel fills. This interpretation is based on its thickness and sedimentary features compared to better exposed deposits described by Bridge and Gordon (1985a, b).

***Description of the interbedded sandstones and mudstones:*** The remainder of the section containing the carbonate bed is composed of decimeter- to meter-thick beds of fine- to very fine-grained sandstone interbedded with red, green and gray mudstone in beds up to a meter thick. *Sandstones* have erosional bases, are generally sheet like, and most fine upward. Thicker sandstones are large-scale cross-stratified whereas small-scale cross-stratification is more common in thinner sandstones. Wave- and current-ripple marks occur on top of some sandstone beds. Unidirectional currents are to the southwest whereas there is no systematic orientation of wave ripple marks. The uppermost 0.5 m of some thick sandstone beds are disrupted by root casts, desiccation cracks, calcareous concretions, and burrows. Drifted plants remains and fish fragments also occur. The thick sandstone bed about 12 m above the quarry floor contains low-angle bedding surfaces that define broad, shallow channel and bar forms. At about 8 m a distinctive, 2 m thick *coarsening-upward bedset* occurs. Mudcracked, wave-ripple cross-stratified and small-scale cross-stratified heterolithic beds (lenticular -> wavy -> flaser beds) grade up into planar-stratified and wave-ripple cross-stratified very-fine grained sandstone. A variety of burrows (including U-shaped *Arenicolites*, horizontal *Planolites*, and small vertical burrows) disrupt the bedset. Wave ripple marks are common on bedding surfaces here. Green mudstone overlies the coarsening-upward bedset, and is sharply overlain by the carbonate bed. The mudstone contains brown carbonate concretions, desiccation cracks, and root casts that penetrate the underlying sandstone. Other *mudstone* beds contain abundant desiccation cracks, burrows, rare fish fragments, and root casts up to 0.5 m long that are rarely encased in micritic carbonate. Channel fills up to 1.1 m deep occur in the mudstone above the carbonate bed.

***Interpretation of the interbedded sandstones and mudstones:*** The interbedded sandstones and mudstones are interpreted as overbank flood deposits associated with crevasse splays, levees, flood-basins and lakes. Bridge and Gordon (1985a, b) described better-exposed examples from nearby roadcuts in the Oneonta Formation. *Sandstone* sheets are generally interpreted as the bedload deposits of individual sheet floods over flat flood-basin surfaces whereas the *mudstone* layers are interpreted as suspended load deposits. The erosional bases and fining-upward character of the sandstones record initial erosion of the flood-basin surface followed by deposition from waning flows. The disrupted upper portions of sandstones and the general disruption of mudstones record colonization by plants, burrowing by organisms, desiccation and calcareous paleosol development. Fine-grained channel fills in the upper mudstones may be flood-basin drainage channels. The sandstone 12 m above the quarry floor is interpreted as a crevasse-splay deposit based on its overall wedge-shaped geometry and internal channel and bar bedding structure. The *coarsening-upward bedset* at 8 m in the section is reckoned to record the progradation of a levee or crevasse splay into a flood-basin area. The progradation is initially recorded by the heterolithic strata which indicate periodic bedload deposition followed by suspended load deposition in ponded water, culminating in desiccation. The planar stratified sandstone in the upper portions of the coarsening-upwards bedset record upper plane bed deposition on the levee or crevasse-splay proper. This levee or crevasse splay may have built into a perennial lake. A lake is inferred from the common vortex ripples and extent and nature of the burrowing in this interval. The abrupt fining at the top of this bedset may be due to avulsion of the main river channel and abandonment of the levee or crevasse splay system (e.g. Bridge 1984).

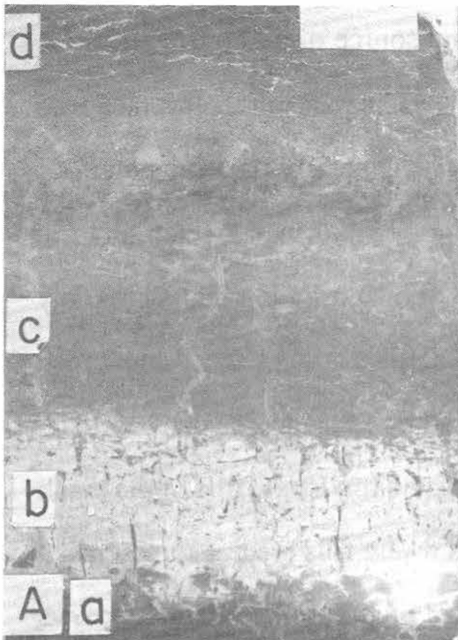
## DESCRIPTION AND INTERPRETATION OF THE CARBONATE BED

The carbonate bed is located about 9.5 m above the base of the section, It is exposed more or less continuously along the 130 m length of the quarry.

***Description of the carbonate bed:*** The carbonate bed varies in thickness from 0.4 - 0.5 m, and is a laminated to massive dolomitic peloidal mudstone that contains 6-23% insoluble residue comprising quartz silt, illite and chlorite with no microfossils. The bed can be divided into four laterally continuous layers each about 0.1 m thick (labelled a to d in Fig. 4A). The sedimentary features of the various layers are similar but vary in degree of burrow disruption and mudcrack disruption (Fig 4B, C, D). Layers are separated by brecciated zones a few centimeters thick as a result of numerous vertical and horizontal mudcracks. Laminae (Fig. 4B) are planar to undulatory and are either millimeter-thick, normally graded lenses of silt-sized peloids and quartz grains or submillimeter-thick mudstone layers traceable for hundreds of millimeters. Laminae commonly contain abundant, spar-filled, vertically oriented tubes 5-15 microns in diameter and up to 1 mm long (Fig. 4E). Laminae in layer b also contain calcispheres up to 0.1 mm in diameter (Fig. 4F) and ostracode shell fragments that become more abundant toward the top of the layer. Mudcracks originate from many surfaces within each layer and many are bridged by horizontal sheet cracks. Toward the top of the carbonate layer, mudcracks are filled with a finely laminated dolomitic mudstone, laminae being parallel to the crack walls. In some cases, crack-fill laminae are symmetrically arranged as in a vein filling (Fig. 4G). Burrows are horizontal and vertical tubes up to 20 mm in diameter (Fig 4D). Tubes up to 3 mm in diameter have simple blocky-spar mosaic cements. Larger diameter tubes commonly have laminated linings, peloids and blocky-spar central fills. Rare coarsening-inward drusy cements leave central voids.

***Interpretation of the carbonate bed:*** The carbonate bed is interpreted to be the deposit of a groundwater-fed, freshwater marsh to shallow lake that developed within a flood basin during a time of local, reduced input of siliciclastic detritus. The carbonate is thought to have originated as mud-sized crystals precipitated around filaments within a cyanobacterial ("blue green algal") mat. Indeed, the micron-diameter tubes preserved in laminae are probably cyanobacterial filament molds.

Figure 4. Sedimentary features of the carbonate bed. A) Polished, etched slab of nearly complete carbonate bed, layers a-d labelled. Scale bar is 50 mm long. B) Preserved undulatory laminae (from layer a). Note large, compacted mudcrack in center of photograph, smaller mudcracks, and burrow (arrow). Scale bar is 50 mm long. C) Bedding plane section of mudcracked laminites. Scale bar is 50 mm long. D) Layer b. Note rare laminae, vertical and horizontal burrow tubes, and brecciated upper surface. Scale bar is 50 mm long. E,F) Thin-section photomicrographs of layer b. E) Alternating laminae of peloidal silt and dense mudstone. Note the micron-scale, vertical tubes (at arrows) and larger, spar-filled burrow tubes. The micron-scale tubes are interpreted as cyanobacterial filament molds. Scale bar is 1 mm. F) Calcispheres (arrows) in burrow-mottled mudstone. Scale bar is 0.2 mm. G) Laminated, horizontal crack fills which are symmetrically arranged ar arrow. Burrow tube cuts crack fill at the extreme right. Scale bar is 50 mm long.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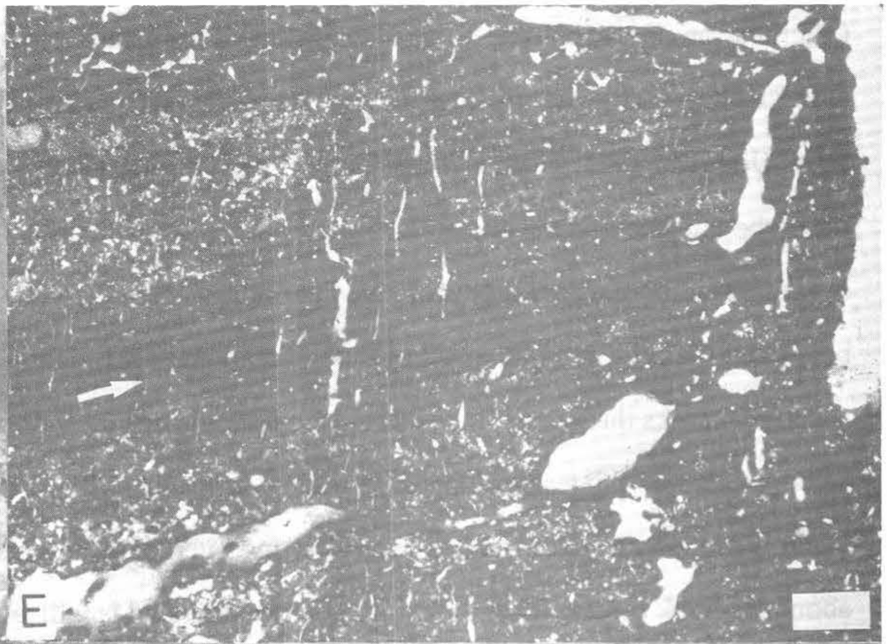
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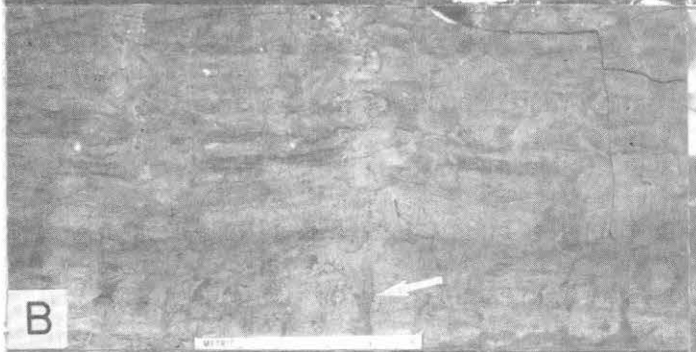
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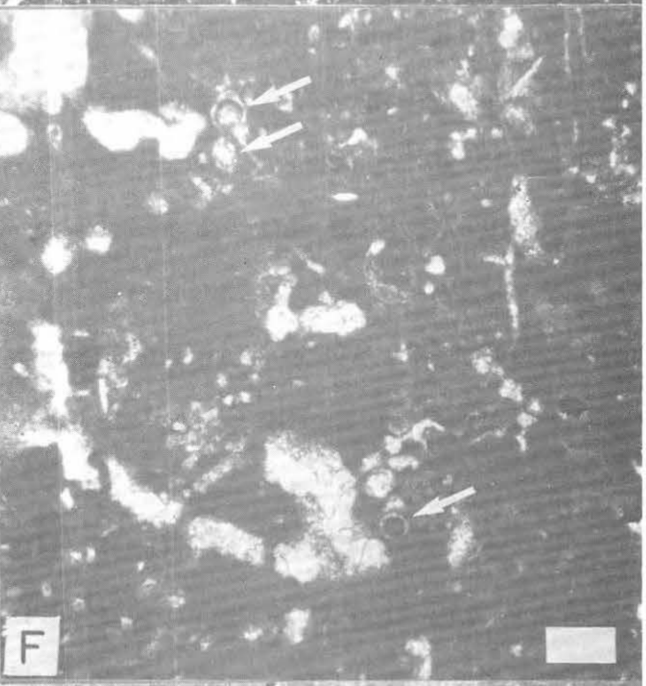
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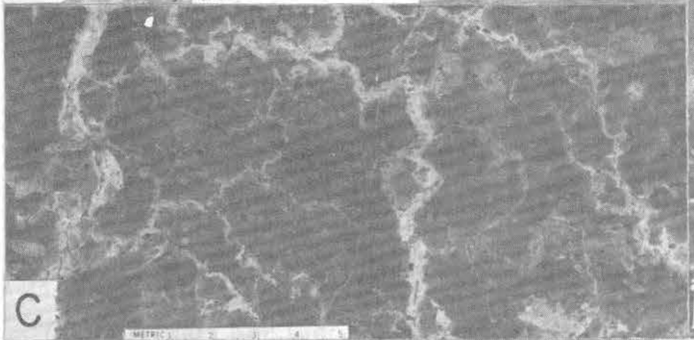
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Calcification of charophytic algae may also have been an important source of carbonate sediment as calcispheres are generally interpreted as the calcified Gyrogonites of Characean or Dasycladacean algae (Johnson 1961; Horowitz and Potter 1971; Flugel 1982). The generally massive nature of the carbonate bed and the preserved burrows suggest it was thoroughly bioturbated which, in turn, suggests that there were fairly prolonged periods of standing water. The burrowing fauna probably pelletized the original mud-sized cyanobacterial and algal debris. However, the small mudcrack and sheet cracks throughout the bed suggest periodic drying and the large mudcracks that brecciate layer boundaries suggest prolonged periods of exposure. The laminated mudstone fills of the crack network are interpreted as micritic cements and internal sediments where fills are not symmetrical about the crack center. That they were not too indurated is indicated by the fact that large burrows cut across them but small one do not.

This carbonate bed is very similar to the carbonate mud deposits of fresh-water marshes and lakes of the Everglades and interior of Andros Island (Gleason and Spackman 1974; Monty and Hardie 1976). These areas are covered by cyanobacterial mats ("Periphyton" of Gleason and Spackman 1974) in which carbonate mud is produced by light calcification of filaments due to local extraction of $CO_2$. Modern periphyton deposits range from complexly mudcracked and brecciated muds in marshy, seasonally-exposed areas to massive and laminated pellet muds in semipermanent lakes.

## IMPLICATIONS OF THIS UNIQUE CARBONATE BED

***Paleoclimate:*** Cyanobacterial marshes and lakes develop in rather specific subtropical climatic settings where short rainy periods alternate with seasonal dry periods (Monty and Hardie 1974). During the rainy periods, marshes become flooded as water tables rise above the surface. Cyanobacterial mats thrive during this submergence, and contribute their seasonal sediment. However, these periods must be short enough to prevent prolonged standing water. Where this happens, higher plants colonize the area and peat is formed. The paleoclimate of the Catskill alluvial plain in New York was probably tropically wet and dry, with a paleolatitude of approximately 20° south of the equator as deduced from a range of sedimentological, paleontological and paleomagnetic evidence (Woodrow and others 1973; Heckel and Witzke 1979; Woodrow 1985; Gordon and Bridge 1987). By way of comparison, average rainflall in the Everglades modern periphyton marshes is about 150 cm/yr with about two-thirds to three-quaters of this rain falling between June and October (Ginsburg 1964).

***Deposition rate:*** The carbonate bed represents a decrease in terrigenous deposition rate, possibly due in part to the diversion away from the area of the major river channel that was supplying the sediment. However, it appears from the degree of bioturbation and calcareous paleosol development in the beds immediately below the carbonate that deposition rates were already low compared to those following carbonate deposition. The carbonate bed cannot be traced beyond the quarry so it is not possible to assess whether the reduced deposition rates were of local or regional importance. The Givetian-Frasnian boundary in New York is marked by a major transgression which had been associated with eustatic sea-level rise and reduced coastal deposition rates (Rickard 1975; Ettensohn 1985b; Johnson and others 1985). However, the carbonate bed was apparently deposited during or immediately after a period of marked regression (Fig. 2) and presumably high regional deposition rates relative fo subsidence and eustatic sea-level rise. The deposition rate of the carbonate bed cannot be directly ascertained. By way of comparison, as much as 3 m of uncompacted algal marsh deposits have accumulated in the Everglades over the last 5,000 years (Monty and Hardie 1976). The carbonate bed, therefore, may have been deposited within a few thousand years.

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# ROAD LOG FOR DEVONIAN (CATSKILL MAGNAFACIES) FRESHWATER-CARBONATE FIELDTRIP

***Route description:*** Travel underneath I88 at exit 15 and turn left onto NY 23, heading east. Go east approximately 7 miles. Immediately past the sign for Davenport Center, turn right sharply (hairpin bend) onto a dirt road. There is a cemetary on the hill above the dirt road. Davenport Quarry is 0.4 miles up the dirt road.