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DISTRIBUTION OF TRACE FOSSILS PRESERVED IN HIGH ENERGY DEPOSITS OF THE POTSDAM SANDSTONE, CHAMPLAIN, NEW YORK

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ABSTRACT

An unusual bedding plane exposure of the Potsdam Sandstone near Champlain, New York, displays sedimentological and paleontological features that are seldom available for study in this formation. Strong marine currents having three vectors of orientation produced trough cross-strata and asymmetrical ripple marks that are indicative of complex tidal settings associated with am inlet or gut between large sand bodies or barrier bars.

Associated with these high energy deposits are the trace fossils *Diplocraterion*(?) sp. and *Phycodes*(?) sp. which colonized the cross-stratified deposits after deposition. *Diplocraterion*(?) sp., a suspension-feeder may have occupied local patches of bottom in the most active current whereas distribution of *Phycodes*(?) sp., a deposit feeder or predator, was controlled by food content of the sediments. In cross-stratified units there are some indications that numbers of *Phycodes*(?) sp. and *Diplocraterion*(?) sp. were inversely related suggesting that there was habitat competition between them. Theoretical considerations regarding the amount of detrital organic matter that one may expect to have associated with cross-stratified sands also suggest that this species of *Phycodes* may have been a predator of microorganisms rather than simply a detrital deposit feeder.

INTRODUCTION

The region immediately south of Champlain, N.Y., is underlain by white or cream-colored, fine and medium-grained, quartz sandstone that is assigned to the Keesville Member of the Potsdam Formation (Fisher, 1982). It can be viewed in local road cuts along N.Y. Route 9, in some farm fields, and in small abandoned quarries exposing 15 feet, or so, of section. One such quarry behind the Clinton Farm Supply Company, 1.1 miles south from Champlain on highway 9, includes a bedding plane exposure that reveals both biologic and sedimentologic properties of the formation that are seldom seen to this degree (Figure 1). In this paper we describe conditions of environment and biota revealed by this exposure and make comparisons with the Potsdam Sandstone in St. Lawrence County.

METHODS

Study of this exposure proceeded by developing a grid of 1-meter squares over the outcrop to serve as a base for mapping both sedimentary structures and ichnofauna. Vectoral data of cross-strata axes and ripple crests were collected within the grid. The resulting map (Figure 2) is drawn with respect to magnetic north. Trace densities within each square were counted to provide a frame of reference for population densities of the trace makers.

SITE DESCRIPTION AND OBSERVATIONS

A continuous plane exposure forms the surface along the north side of the parking lot in front of the Clinton Farm Supply building. The entire surface has been glaciated as evidenced by presence of chatter marks, striae, and a polished surface on the outcrop. This glacially-eroded surface continues on the east side of Route 9, as well, but it is much less dramatic in both ichnofossils and sedimentary structures there.

To the northwest and west of the exposed bedding plane, the overlying bed, an 18 inch-thick, white quartz arenite can be seen. It too, has a rippled surface in places, but is generally not unusual. To the rear of the CFS building lies a small quarry which has been cut into the units being examined. It does not afford any meaningful exposures because it is presently drowned.

STRATIGRAPHY

This site does not offer much stratigraphic data. Reference sections for "Potsdam" strata in the Champlain Valley lie in the Ausable River valley. The lower portion of the formation is reddish, arkosic, subangular to subround, fine-to medium-grained sandstone. Overlying this, as noted above, is a white, subround-to-round, fine-to medium-grained quartz sandstone, the Keesville Member of the Potsdam. The outcrop in question lies in the medial (?) portion of the member.

Stratigraphic relationships with "Potsdam" rocks to the west are not clear, nor are age relationships within the formation. The best regional biostratigraphic index available seems to be the trace fossil *Climacticnites wilsoni* Logan, 1860. Yochelson and Fedonkin (1993) have recently produced an exhaustive study of the paleobiology and paleobiogeography of this strange trace which occurs in the form of a trail made during feeding. *Climacticnites wilsoni* seems to be restricted to Dresbachian rocks in Missouri and Wisconsin. The same trace fossil was first described from sandstones of northern New York, north of Mooers, and Canada

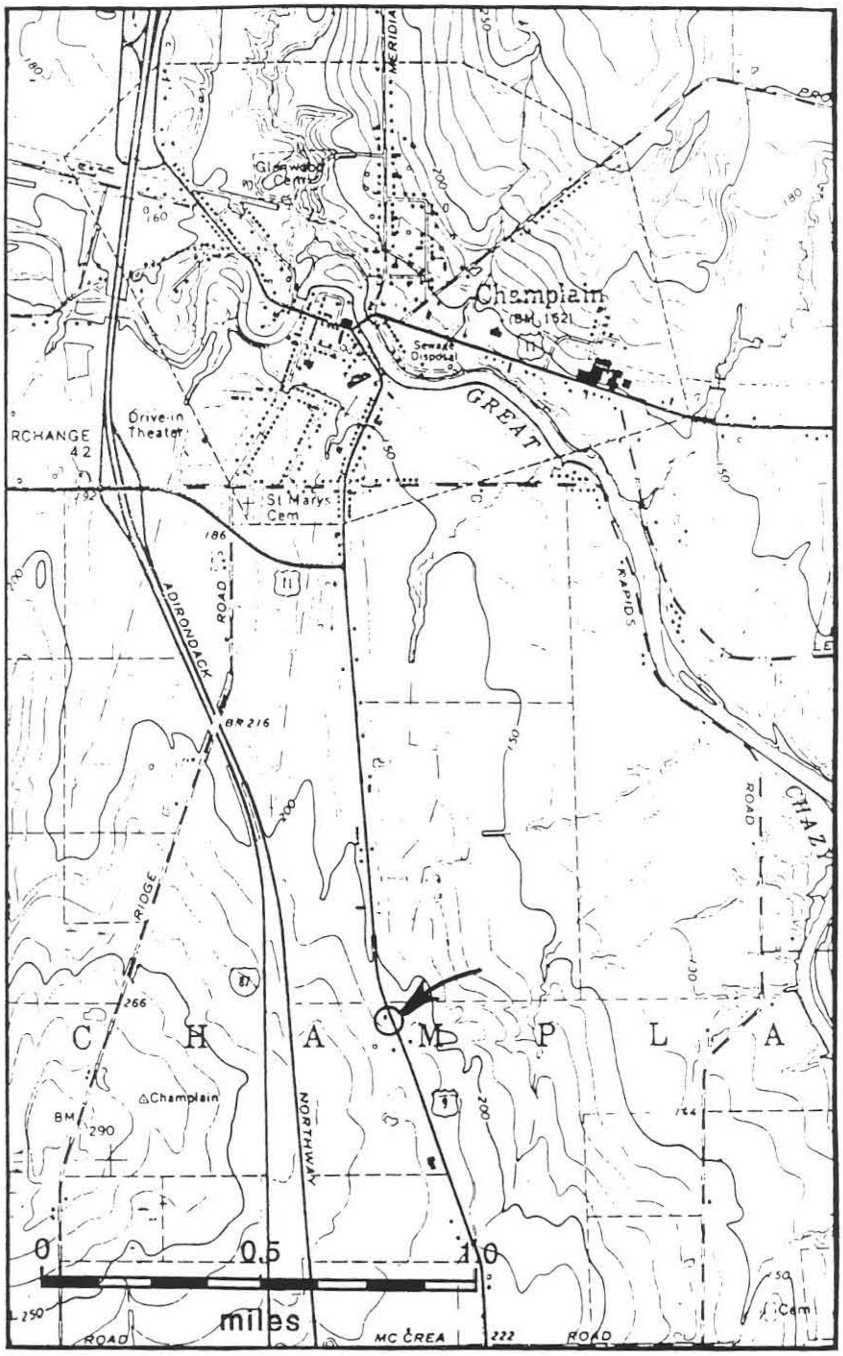

Figure 1: Portion of the Champlain, New York 71/2 minute topographic quadrangle indicating location of the outcrop under discussion herein.

near Perth, Ontario. It is known to occur at Ausable Chasm in the arkosic, Ausable Member and on Wellesley Island where it is found in white, clean, plane-bedded sandstone, but is not known from the type Potsdam nor the surrounding region in St. Lawrence County. In Quebec, Canada, *C. wilsoni* occurs in the Cairnside Formation in the Potsdam Group overlying more than 500 meters of the Covey Hill Formation which in turn rests on Grenvillian basement (Yochelson and Fedonkin, 1993: Hofmann, 1972). Probably the outcrop we describe, with its contained ichnofauna, is post-Dresbachian and pre-Ordovician in age. Local absence of *Climacticnites wilsoni* is most likely due to an absence of rocks representing its preferred intertidal to supratidal flat habitat (Yochelson and Fedonkin, 1993). It would seem that our site was not more than a few meters paleodepth below this. We would welcome discovery of strata containing both *Diplocraterion sp.* and *Climacticnites wilsoni* if such exist.

SEDIMENTARY STRUCTURES

Reference to Figure 2 will permit identification of regions of the outcrop that display large-scale ripple marks and sets of trough cross-strata that have been examined in this study. Cross-cutting relationships record four episodes of large-scale trough migration through a very restricted area. Axial orientations of these sets are designated by episode (Do, D1, D2, D3) on the map in Figure 3. A portion of the complex of sets, D1, D2, and D3 is illustrated by sketch (Figure 4) to point out the three primary axial orientations and their age relationships. Data on axial vectors for 17 axes are presented in Figure 5. Four episodes of trough production resolve into three vector identities that are not the obvious result of a simple, alternating (bi-directional), or tidal, current flow.

Adjacent to the trough cross-strata are examples of large scale, asymmetrical ripples. Although crests of some have been removed by glacial scour, many clearly show steep-sided stoss faces whose direction of migration could be measured perpendicular to the ripple crest. Migration directions again indicate three principal current vectors generally keeping with orientations of cross-strata axes. The stronger tractive current appears to have been associated with ripples designated R1 on Figure 2 and Figure 6 as their wavelength of 38 to 40 cm is almost one-third greater than that of sets R2 and R3. It appears that none were sediment starved.

ICHNOFAUNA

Perhaps the most striking characteristic of the outcrop is the variety of trace fossils preserved in this cross-stratified quartz arenite. The horizon contains a densely burrowed region to the west of the area mapped in Figure 2. That region contains plane bedding which shows *Planolites beverlyensis, Phycodes* sp., *Teichichnus*(?) sp., and possible *Skolithos* sp. Most noteworthy are the ichnotaxa associated with trough cross-strata.

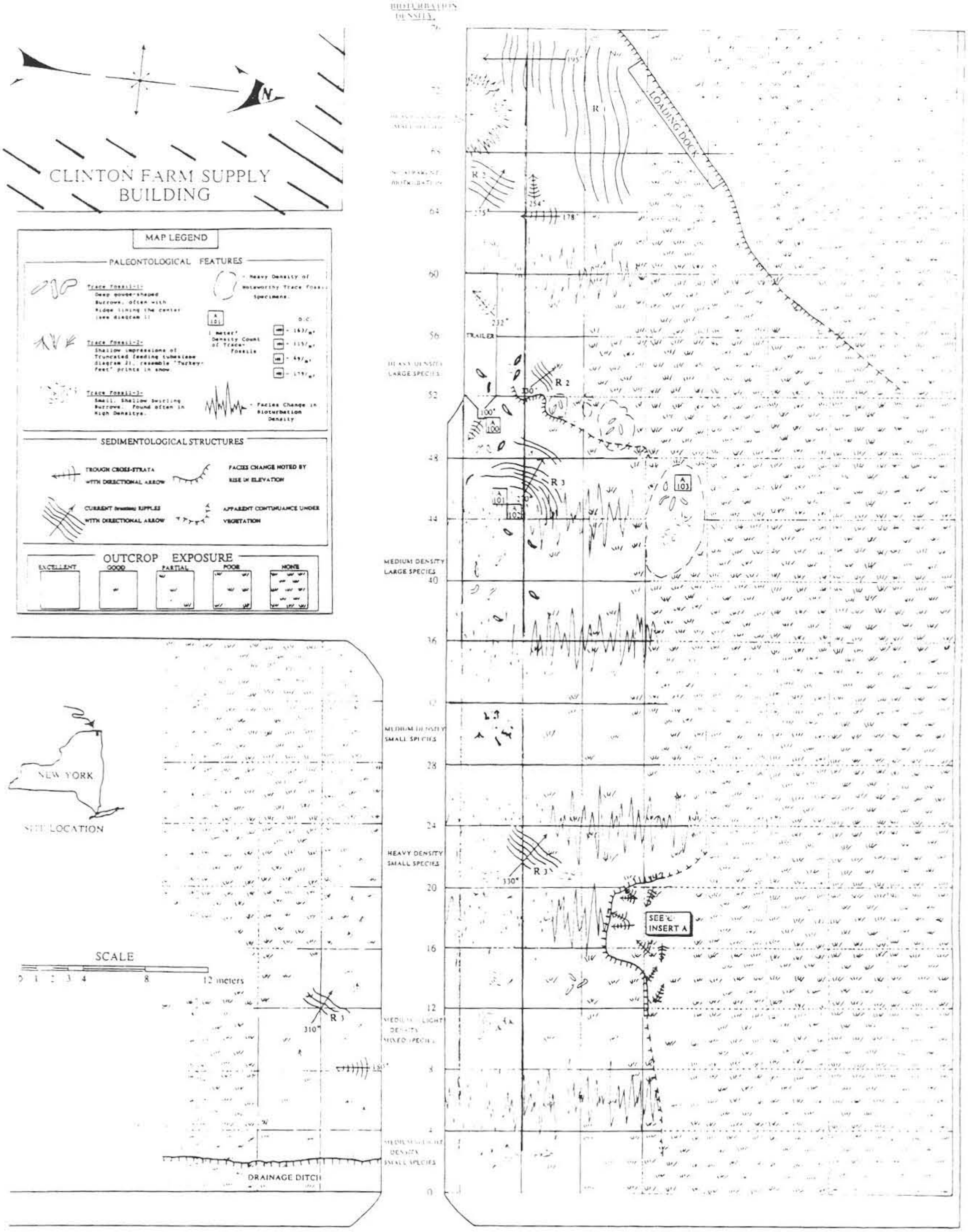

Figure 2: Map of sedimentary structures and ichnofossil distributions on outcrops adjacent to the Clinton Farm Supply building, 1.1 miles south from Champlain, N. Y.

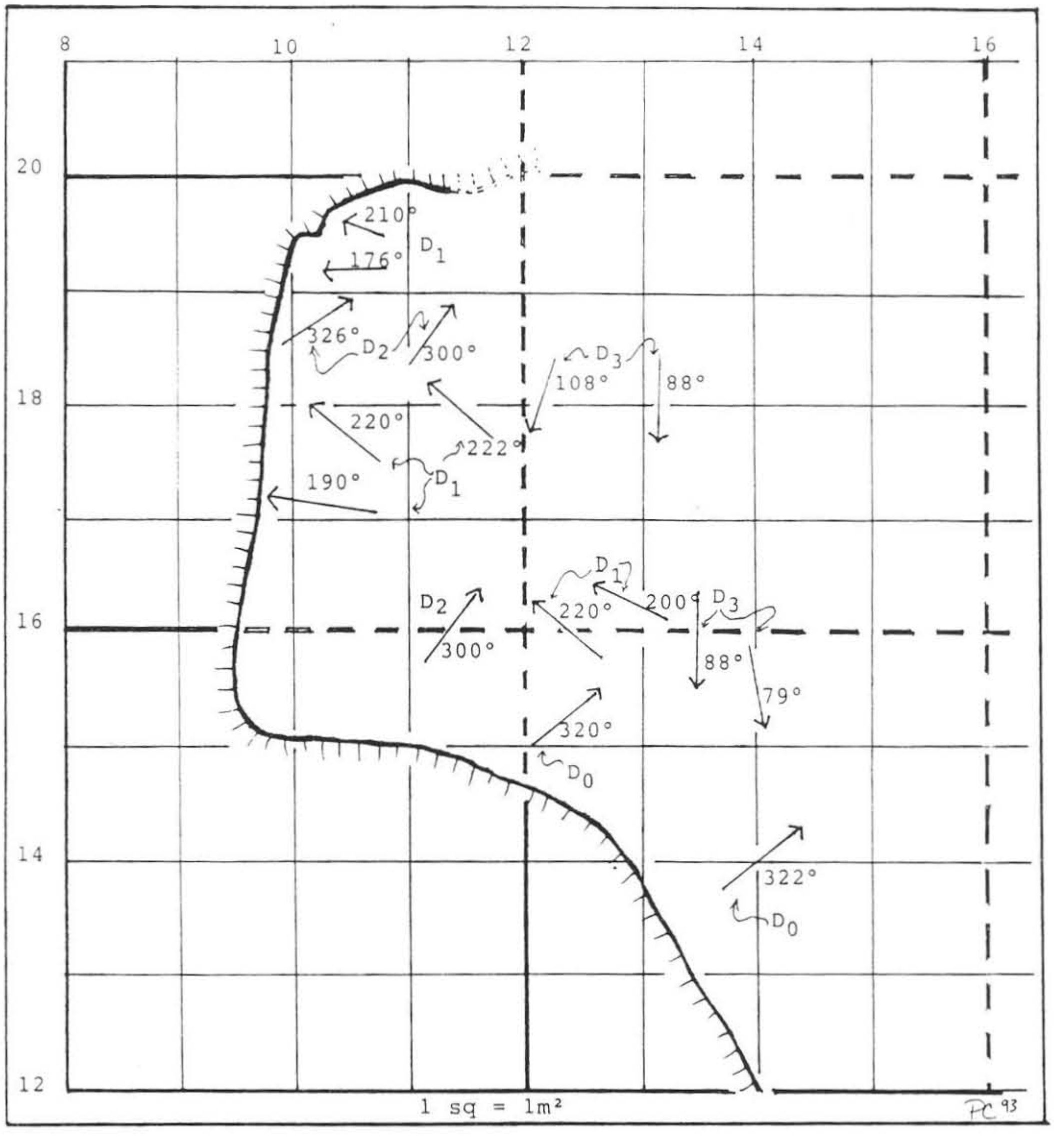

Figure 3: Detail of trough-crossbed axes in area marked "insert A" on Figure 2. Axial orientations are to magnetic north.

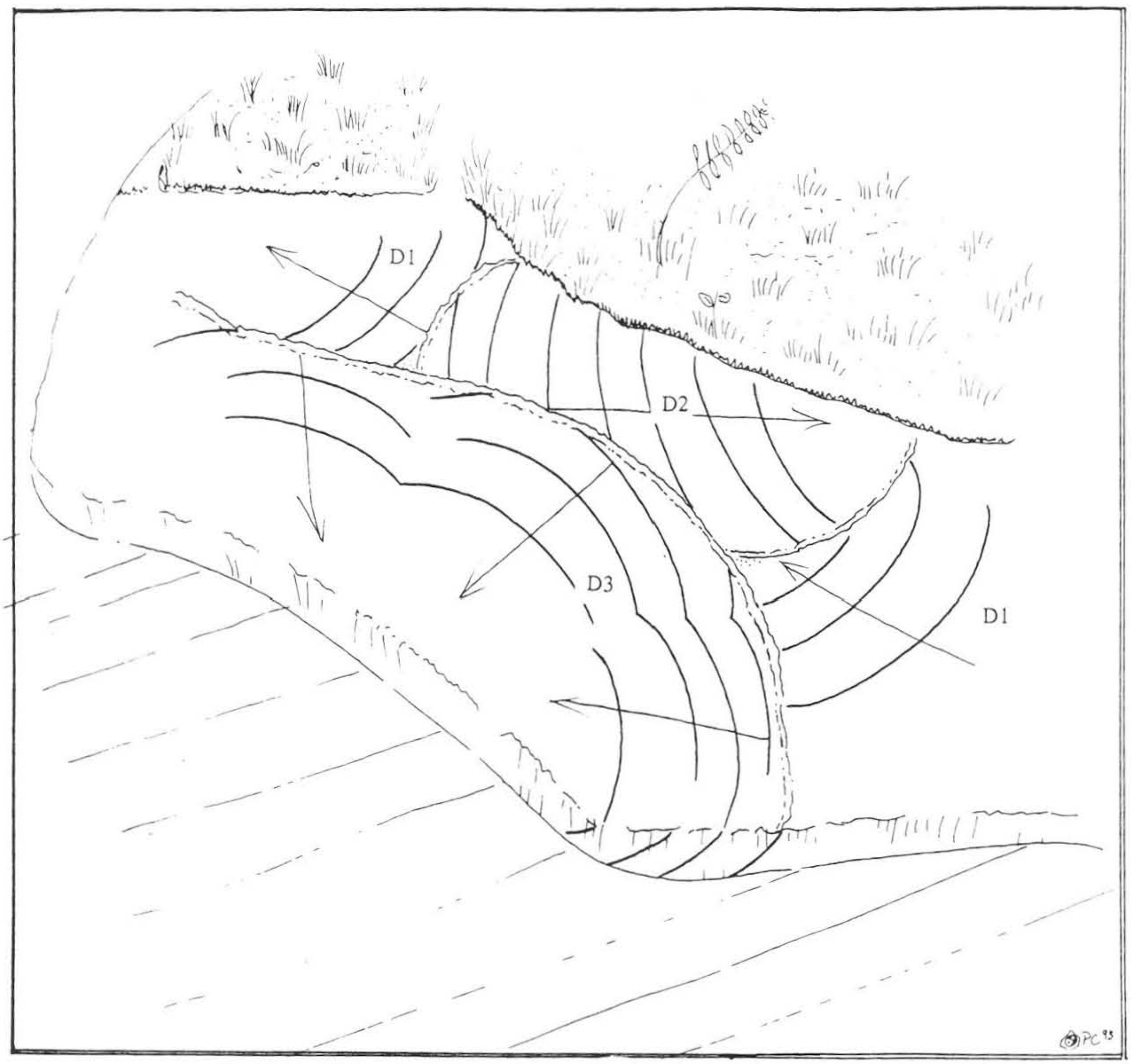

Figure 4: Outcrop sketch of cross-cutting relationships between sets of cross-strata.

Much of the outcrop reveals a gouge, or groove-shaped, trace that appears to be the bottom portion of a u-shaped burrow that has been truncated by glacial scour. Grooves are 1-2 cm wide and 6-8 cm long. Their original height can't be determined. They are widest at the ends reflecting position of the vertical element of the trace (Figure 7). Careful inspection reveals that burrows contain a central ridge interpreted to be spreiten, or a casting, that settled to the floor of the burrow. This relationship was only exposed to the camera in one example (Figure 8) although it was noted many times. In that instance the relationship indicates the body wall of the trace-maker was approximately 4-5 mm in thickness and the gut produced a casting of similar diameter.

The identity of this trace has not been determined with certainty. Evidence suggests that these are the bases of u-shaped tubes of *Diplocraterion* sp. whose appearance on this outcrop is very similar to the "turkey tracks" seen on bedding planes in the Kope Formation of the Cincinnati Arch (Osgood, 1977). Turkey tracks are basal portions of u-shaped tubes assigned to *Diplocraterion biclavatum*, but they are developed in gray shales rather than cross-stratified sandstone. Assignment of these traces to *Diplocraterion*(?) sp. is made with caution.

Population densities of *Diplocraterion*(?) sp. were determined and distributions mapped (Figure 9) across the exposed portions of the outcrops using the grid. Three density levels were established, >115/sq.m., 70-115/sq.m., and <70/sq.m.

Occurring separately from the most dense areas of *Diplocraterion*(?) sp. is another taxon resembling the distal portions of a diminutive species of *Phycodes*. Like the larger tracks these have been truncated by erosion so that they are always seen well below the former sediment-water interface. They appear as empty tubes, 1 to 2 mm in diameter, entering the bed downward at a steep angle and splaying outward from the locus of entry while gradually flattening their angle of penetration to become nearly horizontal. Before splaying, the tubes present a horse-shoe-shaped array of between six and nine openings when crossed by the plane of glacial scour. Definition of the array is lost as tubes change angle of attack toward the horizontal and splay apart.

Diplocraterion(?) sp. and *Phycodes*(?) sp. occur in inverse proportion to each other. Also notably, *Planolites beverlyensis* is absent from the cross-stratified portion of the outcrop as is *Skolithos* sp. Because of the unusual, glacially-eroded view of a high energy depositional regime, this exposure permits some interpretations not easily made from other Potsdam exposures.

INTERPRETATIONS

Outcrop relationships suggest that the local area was an intertidal sandy and muddy flat, somewhat protected, when the flat-bedded, heavily-burrowed *P. beverlyensis* beds west of the CFS building were deposited. Sediments incorporated a richness of organic matter

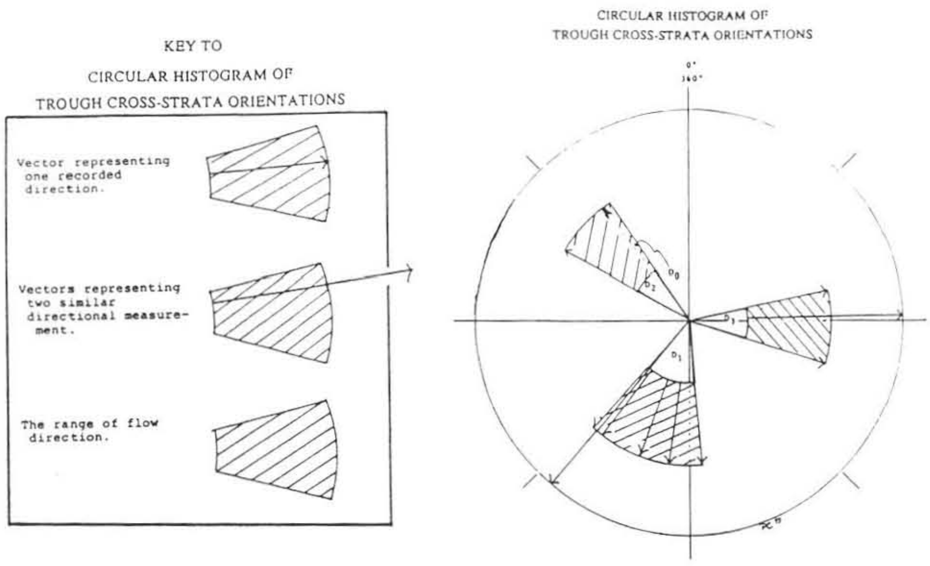

Figure 5: Circular histogram of directional data for axes of trough cross-strata based on magnetic north. N = 14.

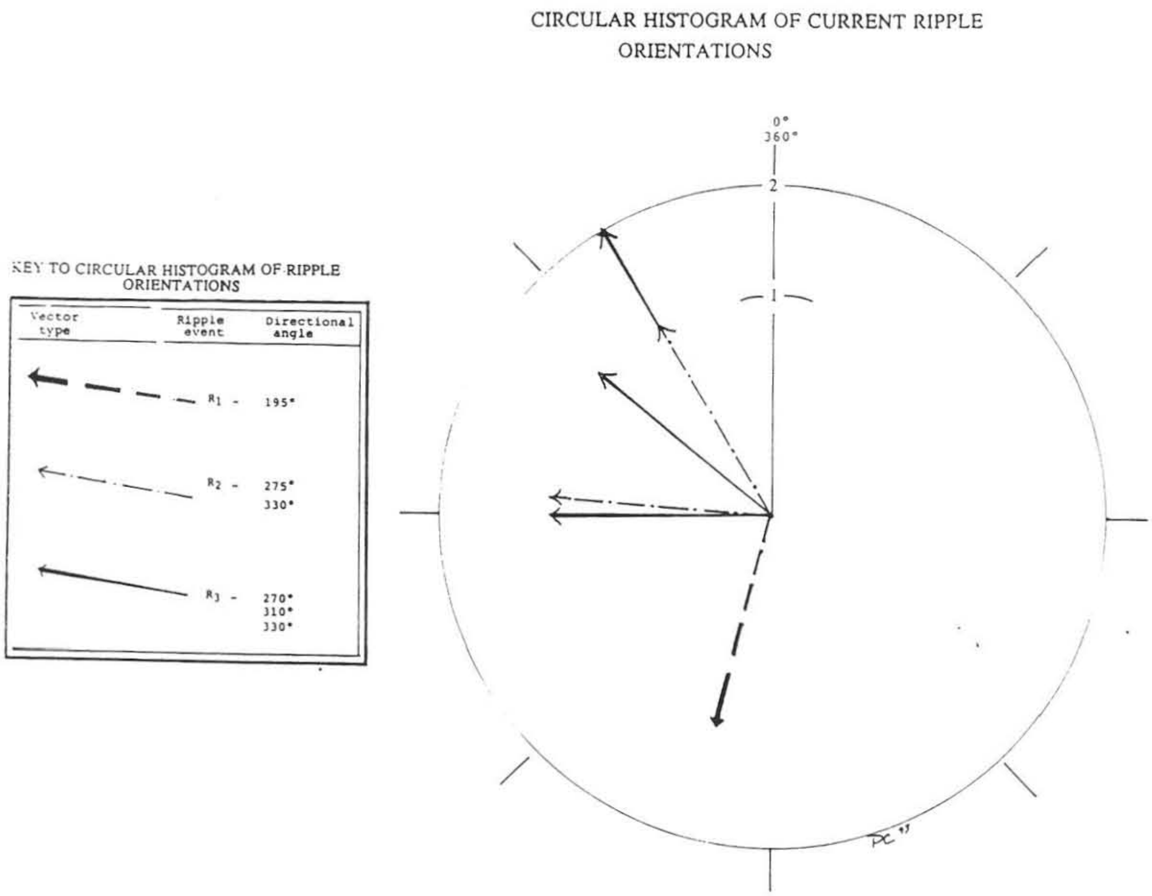

Figure 6: Current directions of asymmetrical ripples based on magnetic north. N = 6.

Figure 7: Bottoms of U-shaped burrows of *Diplocraterion* (?) sp. in grid square A101 (Fig. 2) revealed by glacial erosion of bed. Knife is 9 cm long.

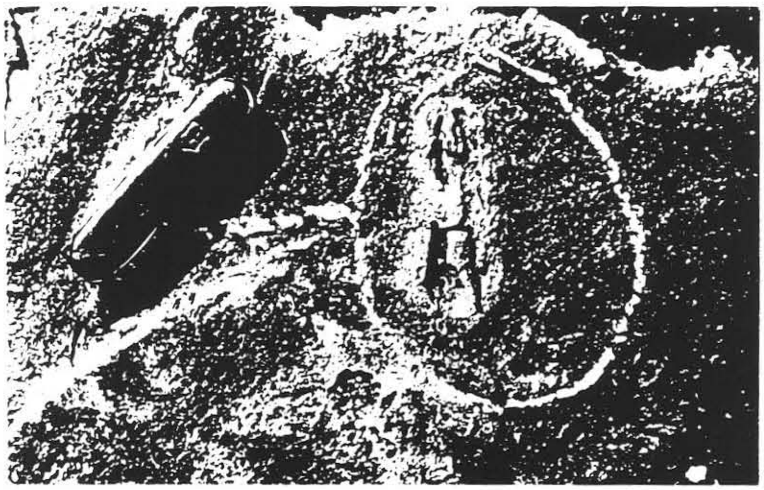

Figure 8: *Diplocraterion* (?) burrow and spreiten remaining in place. Knife is 9 cm long.

Figure 9: View northwestward over part of outcrop at Clinton Farm Supply showing process of laying out 1-meter mapping grids.

exploited by the deposit-feeding burrowers working along preferred horizons. Populations of burrowers were dense. Yochelson and Fedonkin (1993) have suggested that agglutinated foraminiferids may have been numerous in tidal flat sediments. They may have formed some of the food source being utilized here. Other sources for detrital organics must be considered including the possibility that terrestrial organics may have been available for delivery to the tidal flat.

Flat bedded units were dissected by strong currents when the local area was transgressed by a low barrier bar or a spit. Complex current patterns represented by the large-scale three-directional trough cross strata. The complicated current pattern is reminiscent of those developed at the south end of Plum Island on the Massachusetts coast today. There strong tidal flows are occasionally enhanced, or interfered with, by fluvial additions from the estuary behind the barrier island.

In the Potsdam, the strong currents apparently supplied a welcomed habitat for the *Diplocraterion*(?) sp. seen at Champlain. Highest concentrations occur nearest to the most prominent cross-strata. The trace-makers were apparently suspension-feeding organisms which benefitted from current activity. They appear to have been able to burrow deeply enough to prevent being exhumed by the strong currents bringing food.

The *Phycodes*(?) sp. were deposit feeders. They provide some interesting interpretations. It seems they did not prefer to compete with *Diplocraterion*(?) sp. for habitat, perhaps because one simply interfered with the burrowing of the other, making deposit feeding more difficult. Never-the-less presence of the deposit feeder implies presence of organic matter deposited <u>within</u> the cross-stratified sandstones. What form did this food source take? Was it detrital, or may it have been composed of living organisms such as the agglutinated forams mentioned earlier? Obviously an affirmative response would imply that the trace makers were predators, living somewhat like modern scaphopod molluscs, rather than deposit feeders. The narrow diameter of the *Phycodes*(?) sp. burrows suggests that the trace makers themselves were not large organisms, implying that the available food supply was not generous.

Relationships here seem unique in the experience of these authors when compared with the Potsdam Sandstone in St. Lawrence County (Bjerstedt and Erickson, 1989). Those large-scale ripple-cross-stratified sandstones contained *Diplocraterion parallelum* and *Skolithos* sp. without the narrow *Phycodes*(?) sp. seen here. in addition *D. parallelum* in St. Lawrence County rocks is only half the size of the large traces seen in the trough cross-strata at Champlain.

CONCLUSIONS

In conclusion, it appears that conditions of deposition represented by the Clinton Farm Supply outcrop were of unusually high energy when compared with many outcrops of

Potsdam Sandstone that seem to be of the same stratigraphic position to the west. The CFS rocks contain a trace fossil assemblage indicative of this unusual, high-energy, yet food-containing, depositional system. A large species of *Diplocraterion*(?) sp. dominates the suspension-feeder guild whereas a diminutive form of *Phycodes*(?) is the dominant deposit feeder (or predator?) in this habitat-partitioned assemblage.

ACKNOWLEDGMENTS

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Paleoecology students developing ideas about trace fossil trophic and habitat relationships at the Clinton Farm Supply outcrop.

(Photos by J.M.Erickson)