Nearshore Carbonate Sedimentology of the Lowville Limestone, Mid Ordovician, Near Ingham Mills, New York

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Introduction

Some of the most interesting and well exposed Ordovician rock sequences of North America occur in the Mohawk Valley of New York State. Specifically, the Lowville Limestone near Ingham Mills is extremely well exposed due to its outcropping below a dam in an old, abandoned quarry. This carbonate sequence, sometimes referred to as the Gull River Limestone, belongs to the Black River Group which spans from Central New York up into Ontario, Canada (Cameron and Mangion, 1977; Rickard, 1973). The outcrop studied lies within the Little Falls Quadrangle and is near the town of Ingham Mills, which is along the East Canada Creek. Strata in the district are almost perfectly flat-lying. Preexisting studies have dated the Lowville Limestone as Mid Ordovician and cited as being within the *Climacograptus bicarnis* graptolite zone of the Caradocian stage (Keith, 1988; Rickard, 1973). At the quarry studied, the 10 m of Lowville Limestone is sandwiched between two unconformities: below is the Little Falls Dolomite (Cambrian), above, the Denley Limestone of the Trenton Group (Mid Ordovician).

Tectonic Setting

During the Mid Ordovician, the study area is considered to have been situated on a passive carbonate platform that extended over much of the North American craton during the Cambrian and Ordovician. The Taconic orogeny occurred to the east of the platform during Caradocian time; it signaled the intiation of the closing of the Iapatus Ocean. Approximately 65 km to the east of the study area, normal faulting began during Black Riverian time. This faulting moved progressively westward as a result of Taconic thrusting and flexing of the lithospheric plate. Block faulting in the Ingham Mills area is post-Lowville deposition (figure 1). It has been suggested that the Timor Trough is a modern analogue for this tectonic model (Bradley and Kidd, 1991; Cisne et al., 1981).

Observations

Beds at this outcrop are laterally continuous and can be followed for many tens of meters. Overall, the study area represents a transgressive, peritidal sequence that roughly goes from shallow water intertidal to subtidal. Yet within this transgressive sequence there are smaller cycles of relative sea level change as represented by facies migration. Three main facies are observed in this outcrop and they include: A) intertidal, B) subtidal, and C) wave baffle. Contacts are sharp and at least two within the Lowville are erosional.

The intertidal facies consist of externally medium to thick bedded, internally thin laminated to massive, light grey to grey lime mudstone (pelmicrite) that weathers to a buff color. Shaly, perhaps terrigenous, clay layers occasionally interbed with the lime mudstone. Beds within contain one or more of the following: fining up sequences, algal layering, fossil hash, rounded breccia clasts, solution fractures. Intertidal criteria include: aerial exposure as evidenced by occasional, large, well defined mudcracks; prevalent *Skolithos verticalis* and *S. linearis*, common *Paleophycus*, rare *Chondrites* and *Beaconites baretti* trace fossils, and common ostracod allochems. Small scale tidal channels show pinch and swell bedding. These channels are intrinsic to this intertidal model.

The subtidal facies consist of massively bedded, medium to dark grey lime mudstone (biomicrite). Variation in the degree of bioturbation is indicative of rate of sediment input to the system. Where oncolites and many burrows are observed, the rate is slow. Where few burrows are observed, the rate is faster. There is moderate diversity in the fossil fauna; most shells are disarticulated. Presently, the diagnostic fauna found in the subtidal facies are: common brachiopod valves, *Loxoplocus* gastropods, *Actinoceras* nautiloid fragments, broken crinoid stems, *Rugosa zaphrenthis* coral, and abundant *Strictopora labyrinthica* bryozoa and *Hedstroemia* algae. Walker (1972) states that blue-green algal mats dominate the subtidal community here. He noted a protected subtidal/tidal channel in these Lowville facies at Ingham Mills. Lack of dessication features in these facies support the evidence of a permenantly submerged environment.

The wave baffle facies, as Walker coined the term (1972), consist of a massively bedded, medium grey lime mudstone (pelmicrite) that weathers to a buff color. Internally, this facies can be split into two, distinct

In addition, the Tetradium layer in bed 21, a layer traditionally associated with wave baffle margins, would indicate that the environment had moved beyond the protection of the beach ridge. More exhaustive research is needed to accurately determine the more subtle changes in local sea level and environment.

Conclusions

The Lowville Limestone at the Ingham Mills locality represents an ancient tidal flat environment. There are abundant mudcracks concentrated at the upper and lower areas of the formation. There are two sets of channel structures, the lower of which are highly complex. Figure 7 provides one explanation for the sequence of beds and features contained within the formation.

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areas where either in situ *Phytopsis cellulosum* (a growth form of *Tetradium*) or fallen corallites of this genera are present. Both sub-facies have disarticulated shells and some of the subtidal fauna, whereas the in situ sub-facies also has an undetermined form of branching bryozoa. In other words, the division comes from the condition of the *Phytopsis cellulosum.* It is now held that *Tetradium* is a sponge (Yang and Stearn, 1990). There is much brecciation of mud matrix, probably due to infaunal bioturbation, within the growth position sub-facies.

Cathodoluminescence and petrographic analysis has been done on the upper 5 m of the sequence. The results reveal many of the late cements and solution fractures contained fresh or meteoric water. Thus this requires one or more events of salinity change.

Discussion

Recognition of water depth changes in these facies proves to be easier than determining the causes for them. Within the overall transgressive deepening water sequence there are smaller scale cycles of emergence. The nature of these is currently being analysed.

Examining the stratigraphic column and field data at Ingham Mills shows definite facies change that corresponds to the division of induvidual beds or groups of beds. The sequence progresses from shallow water intertidal, to subtidal , then back to intertidal, to wave baffle, and ends with a puzzling bed. This last bed has suspect, vertical, branching tubes that are lined with spar and filled with the mineral hydrocarbon, anthraxolite. The nature of the habitat of anthraxolite i.e. its being observed in solution cracks and burrows of other beds below leads one believe this is a diagenetic feature. Yet work on this problem is in progress. The tubes could have at once been branching burrows and then been expanded after burial. This idea is supported by the intense amount of brecciation throughout. The upper contact with the Denley Limestone is erosional and there is good evidence of a karst surface. Therefore this bed could have deposited in a subtidal environment, fitting into the transgressive sequence, and then was broken down via karstification and erosion before the Denley was deposited. Yet the timing of these events and their relative order needs to be worked out further.

There are several models to consider as to what caused the change in sea level as seen in the rock record. An earlier model suggested that local tectonics caused the sudden break from intertidal to subtidal and rates of subsidence accounted for the relative thickness of the sequence. This model has been weeded-out because the timing of block faulting is post-Lowville. This leaves either an autogenic model or a regional allogenic model to cause the change in sea level. The autogenic model (figure 2) required that facies B was lagoonal and that facies C acted as a wave baffle to protect the intertidal mud flats behind it. This would run the sequence without any sea level change and hence Walther's Law was in effect. If none of the facies B rocks showed fresh water cements, perhaps the fresh water was only affecting the tidal flats/facies A. The allogenic model would be entirely dependant on global or plate-wide sea level change. An area such as the Persian Gulf is an analogue of this in that it has an extremely low gradient coast in which any small fluxuation of sea level would create wide changes in the depositional environments. Finally, it could be a combination of the above. Progress is going on to resolve which model is most feasible via petrographic, C/L, and EDS Backscan analysis.

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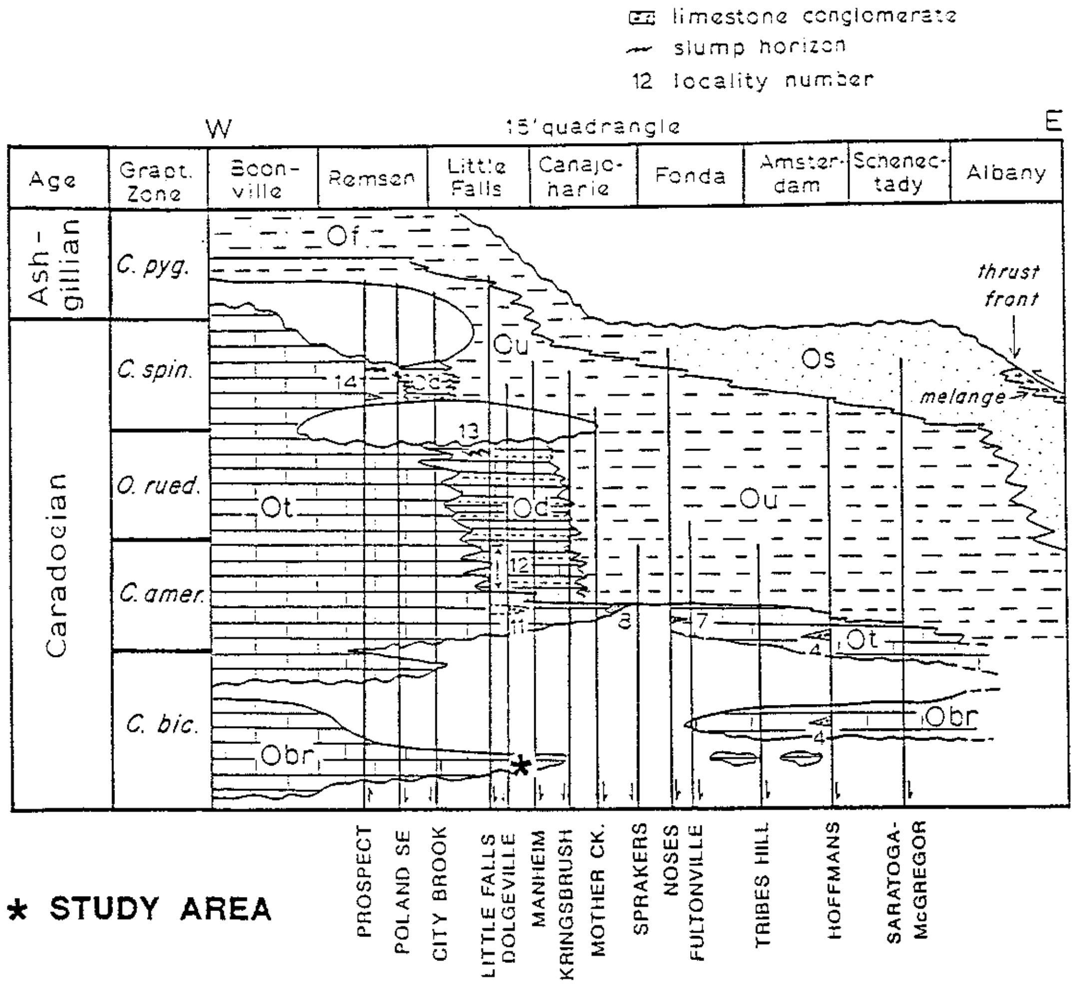

Figure 1. Middle and Upper Ordovician stratigraphy of the Mohawk Valley Region, New York, adapted from Bradley and Kidd (1991). Trenton (Ot) and Black River (Obr) Groups and Dolgeville Facies (Od) comprise the carbonate facies of the cratonic flank of the Taconic foredeep. Utica Shale (Ou), Frankfort Shale (Of), and Schenectady Formation (Os) comprise the upward- and eastward-coarsening siliciclastic fill of the foredeep. Caradocian facies belts migrated westward in response to plate convergence. Bold vertical lines represent Mohawk Valley faults and terminate upward at the time when motion ceased.

Autogenic Model

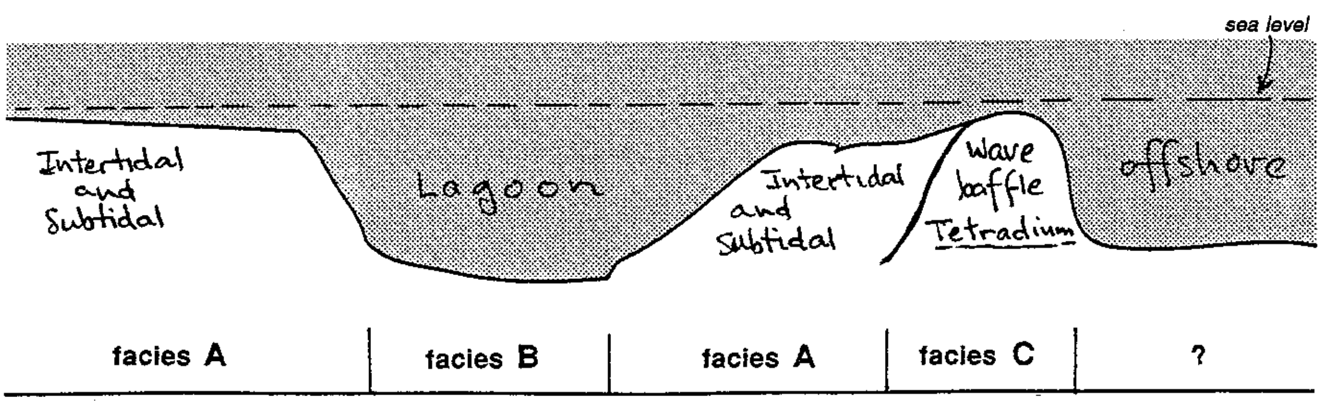

Figure 2