THE LEROY BIOHERM REVISITED -

EVIDENCE OF A COMPLEX DEVELOPMENTAL HISTORY

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INTRODUCTION

The LeRoy Bioherm is among the best known rock exposures in New York State, having been designated a National Fossil Coral Reef by the U.S. National Parks Service and having been the subject (at least in part) of three past studies (Crowley and Poore, 1974; Coughlin, 1980; Lindemann, 1988). Despite this the uniqueness of the LeRoy bioherm has generally gone unnoticed. It is the only Edgecliff bioherm known to have a mound building community of the very delicate branching tabulate coral (Cladopora) and the only known Edgecliff mound with a thickness greater than about 1.2 meters that was not built by phaceloid colonial rugosans (Wolosz, 1992a). Further, the LeRoy Bioherm is the only bioherm in this area with a well developed coral mound facies, while all other Edgecliff bioherms in western New York State are thicket/bank structures (as defined by Wolosz , 1992a).

The ecological zonation of reef building species both within mounds and across reef tracts due to environmental gradients is a well known feature of both Recent and ancient reefs (Wilson, 1975; James, 1983). Hence, the unusual nature of the mound building community at the LeRoy Bioherm (as compared to the typical rugosan dominated Edgecliff mounds), and the size of this cladoporid dominated mound, suggests that environmental conditions in the area must have differed in some way from those prevalent at the other Edgecliff bioherm locations.

LOCATION AND GEOLOGIC SETTING

The LeRoy Bioherm is located in an abandoned quarry near the southeastern corner of the Byron, N.Y. 7.5' quadrangle, approximately 5 km. NNW of the village of LeRoy, N.Y. The Central bioherm is exposed in the middle of the quarry, while a second bioherm is exposed along the southeast wall of the quarry (Fig. 1).

Coughlin (1980) notes the presence of a third bioherm along the west wall of the quarry, but it is very poorly exposed and will not be discussed here.

Geologically, the bioherm is in the western facies area of the Middle Devonian Edgecliff Member of the Onondaga Formation as defined by Oliver (1976). Here, the basal Edgecliff is a transgressive crinoidal grainstone/packstone deposited on a disconformable surface, with the underlying units ranging from the Lower Devonian Bois Blanc Limestone to the Silurian Akron Dolomite (for detailed stratigraphy see Oliver, 1954, 1956, 1976).

PREVIOUS WORK

The three previous studies of the LeRoy Bioherm lacked a basinwide perspective of the Edgecliff and as a result failed to recognize the unique nature of the LeRoy mound building fauna. Poore's study of the bioherm (Crowley and Poore (1974)) is a detailed micro- and biofacies analysis which subdivided the bioherm into ten distinct facies (Figure 2). Coughlin (1980) and Lindemann (1988) both corroborated the presence of these microfacies. Coughlin's (1980) insightful interpretation placed the bioherm in a shallow water, protected environment. Lindemann (1988) interpreted the bioherm as displaying a tripartite ecological succession related to changes in relative water depth, and suggested a moderately deep shelf to shallow subtidal setting for the bioherm. All three workers envisioned the development of the bioherm as one of continuous coral growth upwards into progressively shallower water. Wolosz (1992a, in press) noted that these bioherms are best referred to as a combination of a coral mound and a "thicket\bank" structure - an Edgecliff bioherm in which a pre-existing crinoidal sand bank was colonized by a single phaceloid colonial rugosan thicket. He interpreted the LeRoy bioherm as an extensively eroded coral mound which was first onlapped and buried by crinoidal sand, and later colonized by a rugosan thicket.

THE CENTRAL BIOHERM - CLASSIC INTERPRETATION

Poore's facies map of the Central bioherm (Figure 2) has been the standard interpretation of this structure for the past 25 years. His Inner Core and Outer Core facies have been interpreted as the growth center of the mound, with the Transitional facies representing a surrounding debris rim. The phaceloid colonial rugosans of the Heliophyllum facies have been considered as predominantly in place colonies with the resulting asymmetry of the mound (the Heliophyllum facies is restricted to the east side of the mound) attributed to an "energy shadow" which allowed the rugosans to grow behind the central mound. The remaining facies are primarily flanking beds (with the exception of the Protocap facies which is a colonial rugosan thicket) which were differentiated on the basis

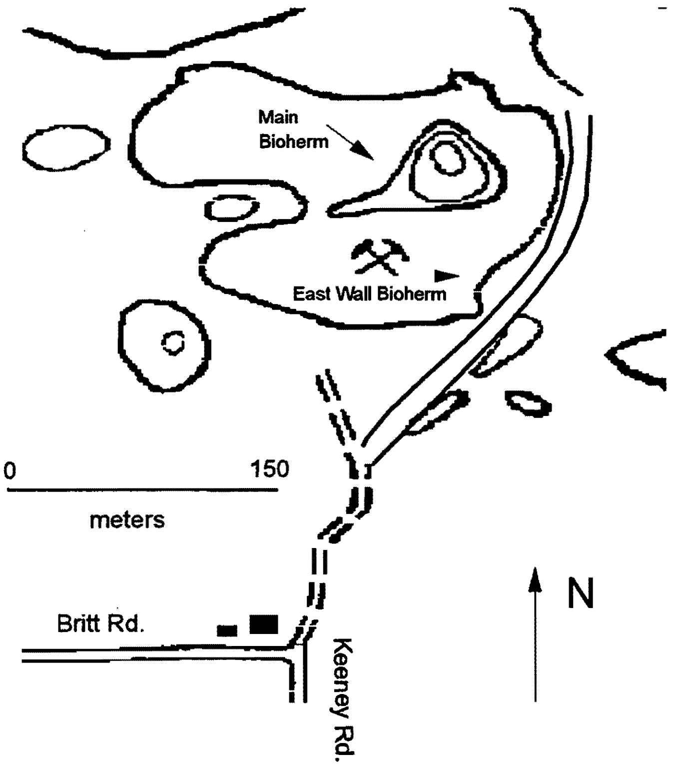


Figure 1: The LeRoy bioherm quarry, showing location of bioherms. Double line on east side of quarry shows current position of road.

of microfacies and/or fossil content, and position - "flank" beds onlap the mound, while "cap" beds cover the mound (for detailed discussion of facies see Crowley and Poore, 1974).

These facies have been interpreted as a record of the transition of the bioherm into shallow water through either simple upward mound growth or due to a shallowing event (Lindemann, 1988), which would not be unusual, especially for Edgecliff bioherms (Wolosz, 1985, 1992b). However, this model fails to explain a number of features which make the LeRoy structure unique among the Edgecliff bioherms.

The organic nature of the bioherm is unusual in two ways. First, the cladoporid mound building community is unique among Edgecliff bioherms. Every other known Edgecliff bioherm has a mound constructed by colonial rugosans, or in the case of some very small mounds, by the tabulate genus Syringopora (Wolosz, 1990, 1992a). Second, the robust branched colonial rugosans (Heliophyllum facies) are interpreted as having grown in a low energy environment ("energy shadow") while the more delicate branched Acinophyllum are found on the high energy side of the mound (Protocap facies) and the mound itself is built by the very delicate and small cladoporids. This would be exactly the opposite of what should be expected based on study of eastern Edgecliff bioherms (Wolosz, 1992b).

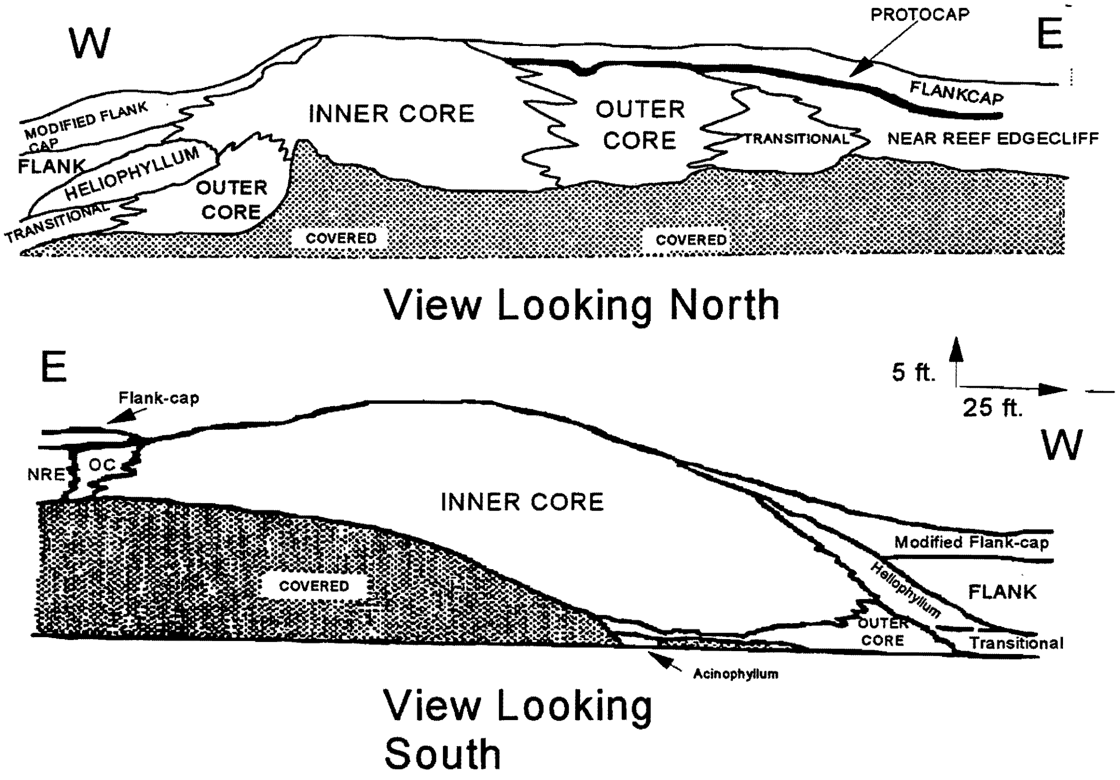
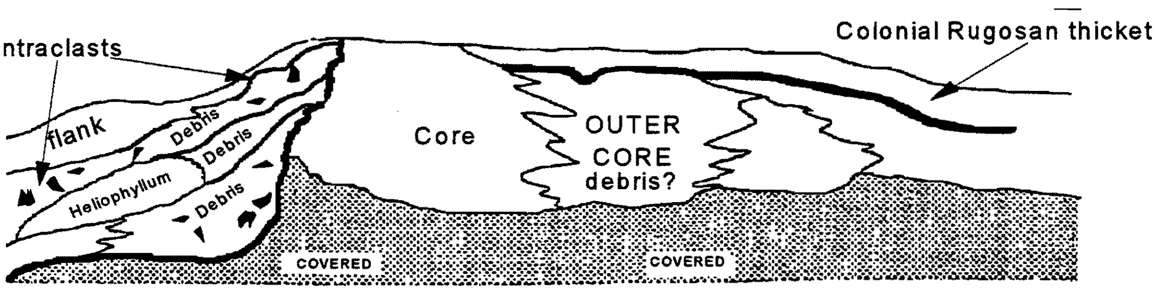


Figure 2: LeRoy bioherm facies as defined and interpreted by Poore. Inner Core, Outer Core (OC) and Transitional facies represent growth center of reef and rubble rim. Heliophyllum facies - in place coral growth in "energy shadow". All other facies are flanking beds differentiated on basis of petrology, fossils and position relative to mound. NRE = Near Reef Edgecliff (for detail see Crowley and Poore, 1974).

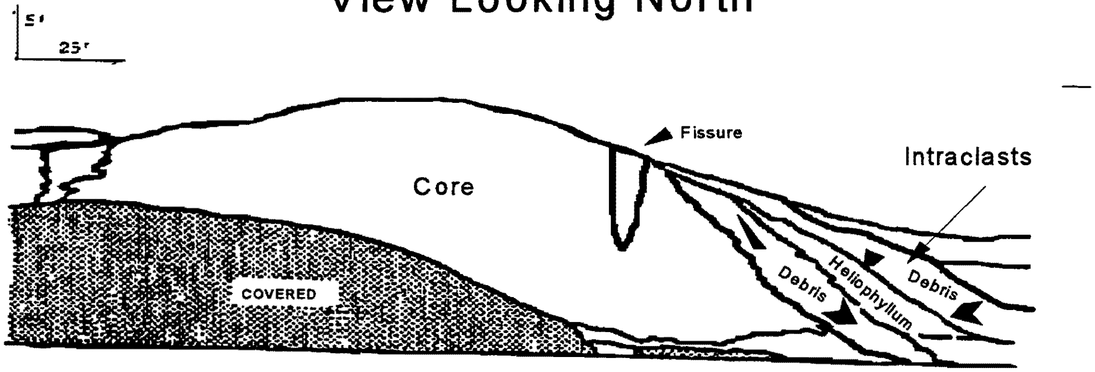
The diagenetic history of the bioherm is also unusual. The bioherm core is the only Edgecliff mound which weathers in a "vuggy" pattern. The partial silicification of the cladoporids in the Inner Core facies represents the only case of notable silicification in any Edgecliff mound.

THE CENTRAL BIOHERM - RECENT INTERPRETATION

Re-examination of the Central bioherm and the east wall bioherm were carried out as part of a regional study of Edgecliff bioherms (Wolosz and Paquette, 1988; Wolosz, 1992a). The re-interpretation of the Central bioherm is illustrated in Figure 3.



View Looking North



View Looking South

Figure 3: Recent interpretation of the LeRoy bioherm. The western end of the exposure is interpreted as core debris rich flank beds. Large, fine grained intraclasts are common both above and below Heliophyllum facies which is considered to be a coral debris apron. Note presence of a fissure cutting core facies.

Contrary to previous interpretations, evidence indicates that the core was subject to extensive erosion prior to the deposition of the capping beds. In thin-section the contact between the core and the overlying facies is a sharp erosional boundary, with fossils within the cladoporid core cleanly truncated at the contact. It is, however, often difficult to find the exact boundary because the flanking debris beds (much of Poore's Outer Core facies) are made up of cladoporid core intraclasts in a matrix of core debris (calcisilt and cladoporid fragments) with only poor contrast between the clasts and the matrix. On the north side of the core a sharp vertical contact marks the presence of a fissure within the core (Figure 3). This contact is easy to miss because the fissure fill consists of fine crinoidal debris in a calcisilt matrix which weathers to the same hue as the core (dark gray), but upon careful examination a distinct textural difference becomes obvious. The initial fissure filling is a fine, calcisilt rich, crinoidal packstone, which grades into a coarse crinoidal grainstone/packstone. Small intraclasts of core facies are common in the fissure filling facies.

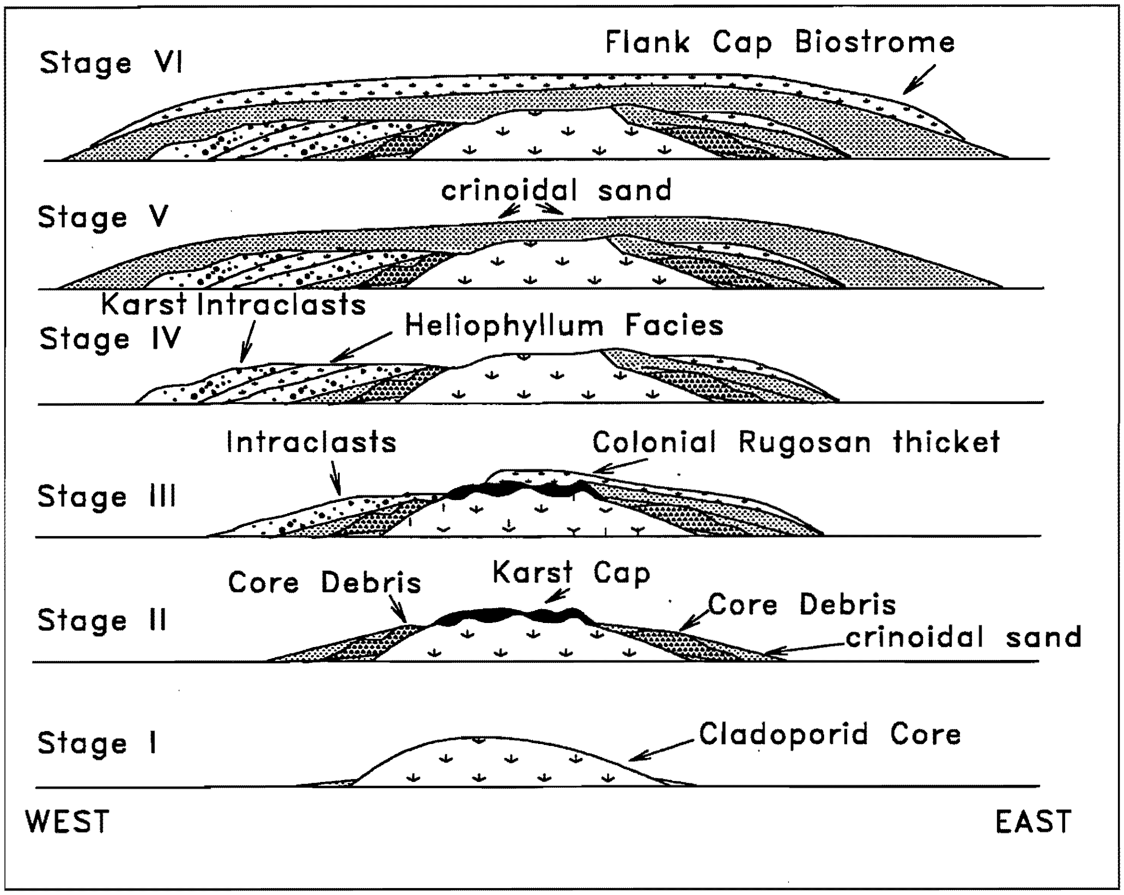


Figure 4: Model for the development of the LeRoy bioherm. Perspective is that of an individual looking north at the central bioherm. "Intraclasts" refers only to intraclasts of karst cap facies. Diagram is not drawn to scale. See text for details.

Large intraclasts are very common in the crinoidal packstones which lap up onto the core on the west side of the exposure. The intraclasts are easily identifiable in outcrop by their light gray, fine-grained, non-fossiliferous appearance. These intraclasts are the only preserved evidence of a mound-capping facies which has been totally removed from the central bioherm exposure. In thin section these intraclasts are composed of fine calcisilt, either massive or weakly laminated, and in some cases containing small fractures filled with smaller intraclasts of the same fine calcisilt. One large fracture contains abraded crinoid grains ranging from nearly complete to fine fragments. These intraclasts, in light of the fissures described above, are interpreted as remnants of a thin karsted cap which has been eroded from the upper portions of the mound.

Finally, the large phaceloid rugosans (Heliophyllum facies) are interpreted as colonies which had occupied the crest of the mound (probably a continuation of Poore's Protocap facies), but which were later displaced into the back-mound area. It is important to note that the fine grained intraclasts can be found both above and below the colonial rugosan horizon indicating continued erosion of the mound following growth and destruction of the rugosan thicket.

EAST WALL BIOHERM.

The east wall bioherm is not well exposed, but does lend support for this new interpretation of the Central bioherm.

Core facies of the east wall bioherm extend to the top of the quarry wall, but an exposure recessed back from the quarry edge among the trees displays a capping colonial rugosan thicket. The thicket does not directly overlie the core, being separated from it by roughly 2 meters of packstone. Further to the north, along the quarry wall, another thicket is exposed which is separated from the top of the core facies by only about 0.2 meter. This second horizon would, based on its relationship to the core facies, be equivalent to Poore's (Crowley and Poore, 1974) Protocap facies. The stratigraphically higher thicket is equivalent to a dense rugosan/favositid biostrome which caps Poore's Flank Cap facies along the eastern edge of the Central mound exposure, and is separated from the Protocap facies by roughly 2 meters of grainstone and packstone.

The presence and position of these colonial rugosan thickets proves that the cladoporid core was at least partially buried by carbonate sand and silt prior to growth of the first thicket and was totally buried prior to development of the second. Hence, the LeRoy bioherm is best described as a thicket\bank structure (Wolosz, 1992, in press). Further, any removal of colonial rugosans from the crest of the mound would form a debris apron. The thickness of the Heliophyllum facies, its onlapping position, and its interfingering with mound debris clearly supports its interpretation as a coral debris apron.

DEVELOPMENTAL HISTORY

This new data leads to a reinterpretation of the developmental history of these bioherms, which can now be seen as a five stage process (Figure 4), and not a simple community succession due to growth into shallow water. Also, this reinterpretation answers some of the questions noted previously.

Stage I: Core growth. The cladoporid core at LeRoy represents growth in shallow, wave agitated water, with conditions generally similar to those described by

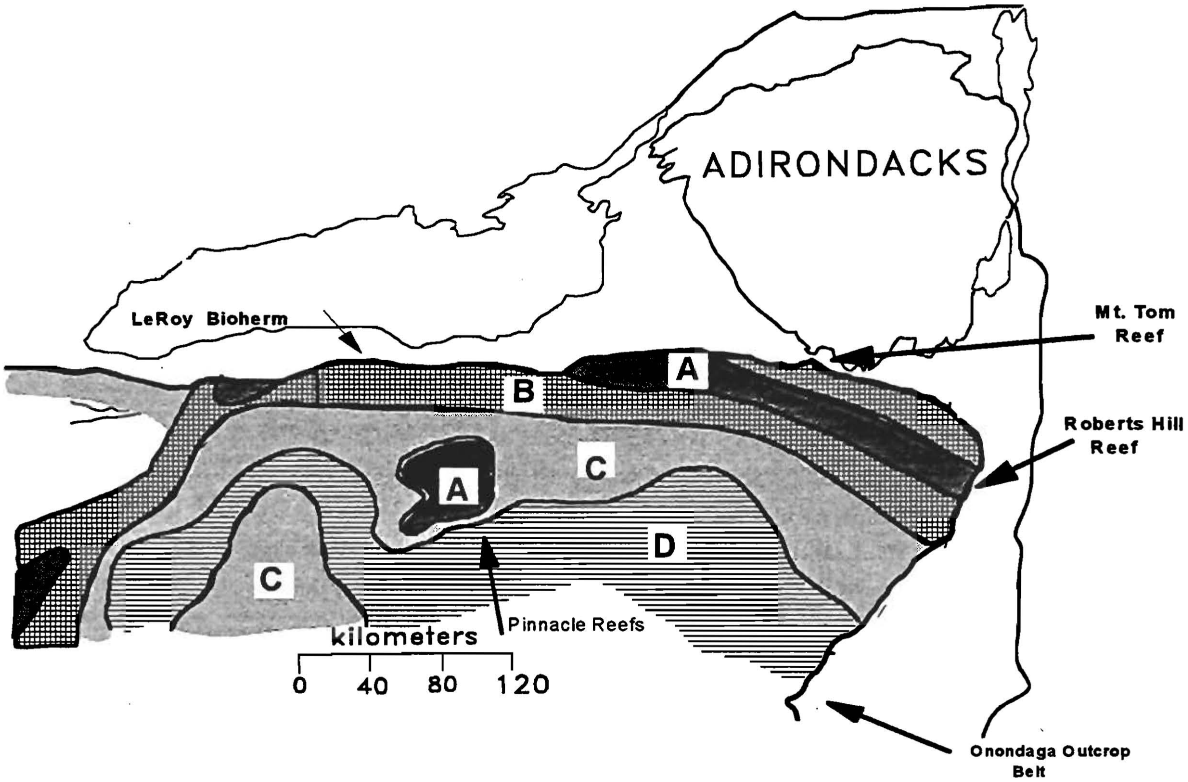


Figure 5: Subsurface facies map of the basal Edgecliff Member of the Onondaga Formation. A = Grainstone; B = packstone; C = wackestone; D = mudstone or nondeposition. Note that presence of pinnacle reef area appears to result in an embayment in carbonate facies to the west. (Redrawn from Cassa (1980)).

Turmel and Swanson (1976) for Rodriguez Key, Florida (see also, James, 1983, p.373-374). The delicate branching nature of the cladoporids precludes high energy conditions, and the lack of any major development of colonial rugosans other than the initial Acinophyllum horizon (Figure 2) also argues for quiet water (see Wolosz, 1992b).

Stage II: Lowering of sea-level results in initial erosion of mound, and deposition of debris flanks, followed by subaerial exposure and the development of a thin karst cap. Minor silicification of cladoporids and early diagenetic modification of the core (resulting in its "vuggy" appearance) occurs at this time. Diagenetic processes are similar to those described by Moore, et al. (1980) for a Cretaceous carbonate beach.

Stage III: Rise in sea-level and overall environmental energy causes partial erosion of karst cap (intraclasts deposited in back-reef). Continued sea-level rise results in colonial rugosan thicket formation (Protocap facies of Crowley and Poore, 1974) which covers the eastern side of the mound.

Stage IV: Second (minor) lowering of sea-level results in scouring of colonial rugosans from the crest of the mound and deposition as rubble apron (Heliophyllum facies). Continued lower sea-level results in renewed erosion of the mound following erosion of karst facies remnants (intraclasts found above Heliophyllum facies).

Stage V: Shallow depth conditions continue, leading to burial of the mound by shallow water crinoidal sand.

Stage VI: Slight sea-level rise results in development of coral biostrome at central bioherm (upper portion of Flank Cap facies at eastern end of exposure) and second rugosan thicket at east wall bioherm.

Note that major sea-level fluctuations are not required by this developmental model. Transition from mound growth to erosion only requires a change from a protected to an open environment with greater wave energy. Following subaerial exposure, erosion and burial of the mound could have been accomplished by fluctuation in sea level of a few meters or less.

DEPOSITIONAL ENVIRONMENT AND CORRELATION WITH OTHER EDGECLIFF REEFS

Coughlin's (1980) assessment of the environment of deposition of the LeRoy core as being a protected, quiet water environment, possibly in the lee of islands of Silurian rock, exhibited great insight. However, it is possible that the protected environment necessary for this unique mound building community may have been provided by the topography of the basin itself, rather than erosional remnants of pre-existing limestone. Cassa (1980) compiled a subsurface facies map of the Edgecliff which presents some interesting data (Figure 5). This map depicts the Edgecliff pinnacle reefs as having been initiated on a grainstone base roughly 80 to 110 km. southeast of LeRoy, but her facies map also appears to depict a type of embayment. The presence of shoals to the southeast of LeRoy would have damped any open ocean waves and resulted in an environment subject only to wind-driven waves near LeRoy. Later subsidence which led to the growth of the pinnacle reefs would have removed much of the original barrier and resulted in a more open environment around the bioherm.

CONCLUSIONS

Current evidence leads to a re-evaluation of the development of the LeRoy bioherm. The classic interpretation of simple upwards mound growth into shallower water is no longer tenable. The current model interprets the development of the bioherm as a five stage process which includes the growth of a quiet water cladoporid mound followed by subaerial exposure and erosion and finally reimmersion in shallow waters. This new model accounts for the unusual mound building community, the positioning of the colonial rugosans of the Heliophyllum facies, and the diagenesis of the mound.

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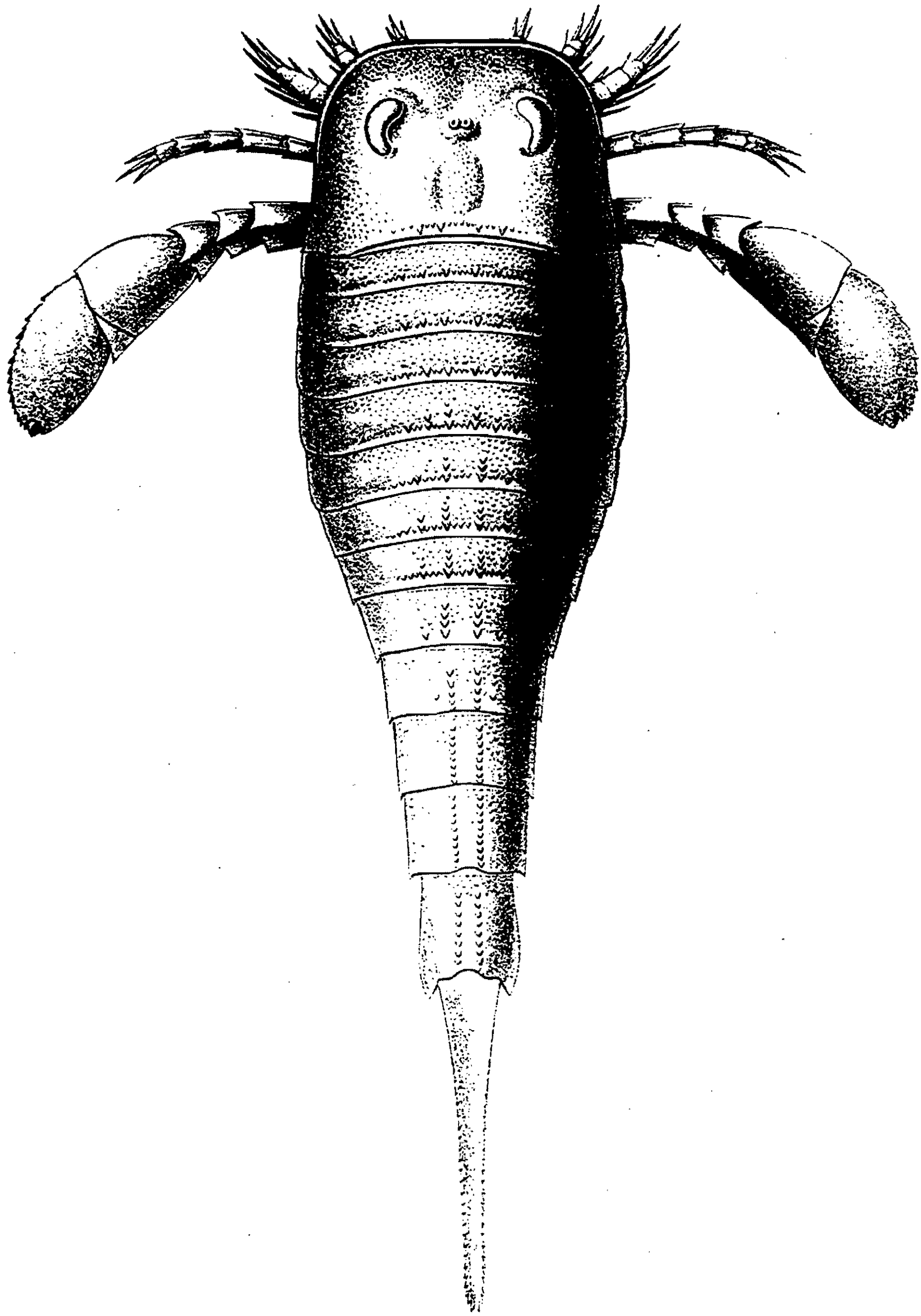
ROAD LOG

CUMULATIVE MILEAGE	MILES FROM LAST POINT	ROUTE DESCRIPTION
0	0	Intersection of Route 5 and 19 in village of LeRoy, N.Y. Proceed north on Route 19.
2.1	2.1	Left turn (west) onto Richmond Road
3.8	1.7	Right turn (north) onto Keeney road.
4.1	0.3	Road turns due west, becoming Britt Road (see Figure 1 in text). Stop at curve, road leading into quarry is overgrown. Walk past east side of house on north side of road to dirt road. Follow dirt road into quarry.

NOTE: PLEASE ASK PERMISSION AT HOUSE BEFORE ENTERING PROPERTY.

LEROY BIOHERM

The most direct entrance into the quarry is down the talus slope which covers much of the east wall bioherm. From the top of the quarry wall the central bioherm can clearly be seen in the center of the quarry pit. The core facies of the bioherm are massive, weathering to a dark gray and can be easily differentiated from the bedded flanking facies which are very light gray to almost white limestone (see text for description). The quarry walls consist of highly fossiliferous Edgecliff shallow marine facies.



Eurypterus remipes remipes

[From Clarke and Ruedemann, 1912. Eurypterida of New York. N.Y.S. Museum Memior 14, Plate 2.]