Evidence of Algal Source of Micrite in a Saluda Coral Zone in Southeastern Indiana

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Introduction

The Saluda Formation has received considerable study (1, 2, 3, 4, 6, 9), as indeed is the case with other Cincinnatian (Upper Ordovician) lithostratigraphic units. Compared to other Cincinnatian (particularly Richmondian) formations, however, the Saluda is lithologically distinct, being typically dolomitic and poorly fossiliferous. The prevalent lithology of the Saluda is either calcitic dolomite or dolomitic micritic (micro-to cryptocrystalline calcium carbonate) limestone (3). Developmentally, the Saluda again provides contrast to other Cincinnatian strata in that it is in all probability the product of a lagoonal setting. Specifically, the Saluda is considered to have originated from a shallow, penesaline, atoll lagoon (3, 4, 9); associated tectonism perhaps represented the inception of the Cincinnati Arch (9). The contour of the Saluda Formation, biconvex and lens-like (3), reflects this ontogeny.

The only really characteristic fossils of the Saluda are the compound corals, *Favistella alveolata* and *Tetradium approximatum* (4). These two corals, singly or together, tend to form a biostromal zone (or zones), especially in Lower Saluda rocks (3, 4, 9). The coralline zone is of considerable paleoecological significance in that it represents the remains of a low, but broad, wave-resistant bank of corals (and other organisms) which essentially circumscribed the Saluda lagoon (3). Circumscription by this coral shoal produced a barrier which significantly altered depositional environment, restricting conditions lagoonward as compared with the surrounding epeiric sea. Environmental restrictions of the shallow lagoon eventually led to increased evaporation rates, salinity, and dolomitization (perhaps penecontemporaneous) within the lagoon (3, 9).

The encircling coralline zone *per se* is not so highly dolomitic, and contains an abundance of micrite. The often massive coral colonies are in some cases haphazardly oriented, indicating at least sporadic turbulent conditions of the surrounding sea (3). This relatively high energy coralline zone more or less effectively delimited the low energy (quiet water) lagoon from the moderate energy epeiric sea (9). The term "reef" is not applied to the coralline zone because of the lack of consistent structural consolidation (3).

As discussed by Van Hart (9) an apparent textural anomaly exists between evidence of a coral bank reflecting turbulent conditions and the presence (in association with the corals) of substantial amounts of ooze (micrite), which would presumably have been winnowed away by the turbulence. Van Hart speculated that the coralline zone might in fact represent a coral/algal complex, and that algal mats could have been the source of the persistent micrite which can be seen in some cases to connect and even surround the coral colonies. Although entirely logical, this idea has remained as speculation. Direct evidence of algae or of definitive algal micrite in the Saluda coralline zone has not been satisfactorily demonstrated. It is to this end that this investigation was directed.

Materials and Methods

Samples were collected at two exposures of the Saluda Formation in eastern Indiana. The first locality is on a roadcut along Highway 101, approximately 5 miles north of Brookville (4.5 miles north of the Brookville Lake Flood Control Station). This is the locality designated as "Brookville North" by Hay (5). The thin exposure of the Saluda at this locality consists primarily of *Tetradium* colonies. Hay considered this exposure of the Saluda to represent the "feather edge" of the formation (personal communication). The second locality is 1.1 miles northwest of Versailles on Highway 421 (north), 0.2 miles north of the divergence of Highways 421 and 50. Specifically, the locality occurs several hundred yards east of the road in the middle of the "west branch" of Cedar Creek; here a zone of *Tetradium* occurs within the confines of eight to nine feet of exposed Lower Saluda sediments (4, 9). In collecting specimens, care was taken to sample both colonial coral (*Tetradium*) material and, as well, intercalary micritic limestone areas. More than 60 thin sections were prepared, by standard techniques, divided equally between the two localities discussed. Slides and samples are deposited in the paleobotanical collection associated with the Herbarium at Miami University (MU).

Results and Discussion

Thin sections prepared of samples taken from *Tetradium* colonies often revealed associated micrite. Conversely, sectioned intercalary limestone samples frequently contained *Tetradium* fragments. A clear association is thus apparent between the colonial corals, or their fragments, and probable *in situ* micrite. Invertebrate fossils (other than corals) found in the micrite of the coralline zone are reasonably abundant and usually fragmentary (3), with Ostracodes perhaps most commonly observed. Such fragmentary constituents, trapped in the micrite, are doubtless allochthonous with respect to the fundamentally autochthonous coralline zone. Monticuliporid bryozoans are occasionally layered external to the surface of *Tetradium* colonies, and possibly constituted a minor *in situ* component of the coral bank.

Microscopic examination of micritic regions in thin section generally supports the hypothesis (9) of a predominantly algal source of micrite in the coralline zone. The visible evidence is admittedly variable, however. A sliding scale exists between areas of pure opaque micrite and those exhibiting more or less distinct calcareous algal tubes. In either "extreme," or examples in between, an intimate relationship of algal micrites with surfaces of the *Tetradium* colonies may be observed. In clearest examples algae appear to have grown as encrusting masses directly upon *Tetradium* (Figure). Based on tube diameter, morphology, and irregularity, these fossil algae bear a greater resemblance to cyanophytes than to rhodophytes or chlorophytes (12).

Microscopic observations made on micrites of the Saluda coralline zone are consistent with those of Wolf (11) on certain Australian Devonian and Recent algal deposits. In both Holocene and Paleozoic examples, Wolf observed the product of an apparently gradational grain diminution of calcareous algal cells and filaments to cryptocrystalline calcium carbonate. Wolf considered this "decrease in detail" to be an early diagenetic phenomenon. He discussed the possibility that algal tissue perhaps served bacteria nutritionally, and that subsequent to bacterial delay, the calcareous algal remains may have become reduced to detrital micrite and then lithified. Wolf (11) pointed to the need for experimentation to substantiate bacterial decay as a cause of algal micritization, as opposed to disintegration solely by mechanical abrasion (10). Regardless, Wolf concluded that a great deal of enigmatic biohermal or knoll reef micrite may be explained by grain diminution of algal colonies.

My observations thus correspond to Wolf's (11) on textural alteration, and also support Van Hart's (9) hypothesis of the importance of algae in the development of the Saluda *Tetradium* zone. In more general terms these observations are consistent with the belief in the significant contribution of algae to many limestones and lime

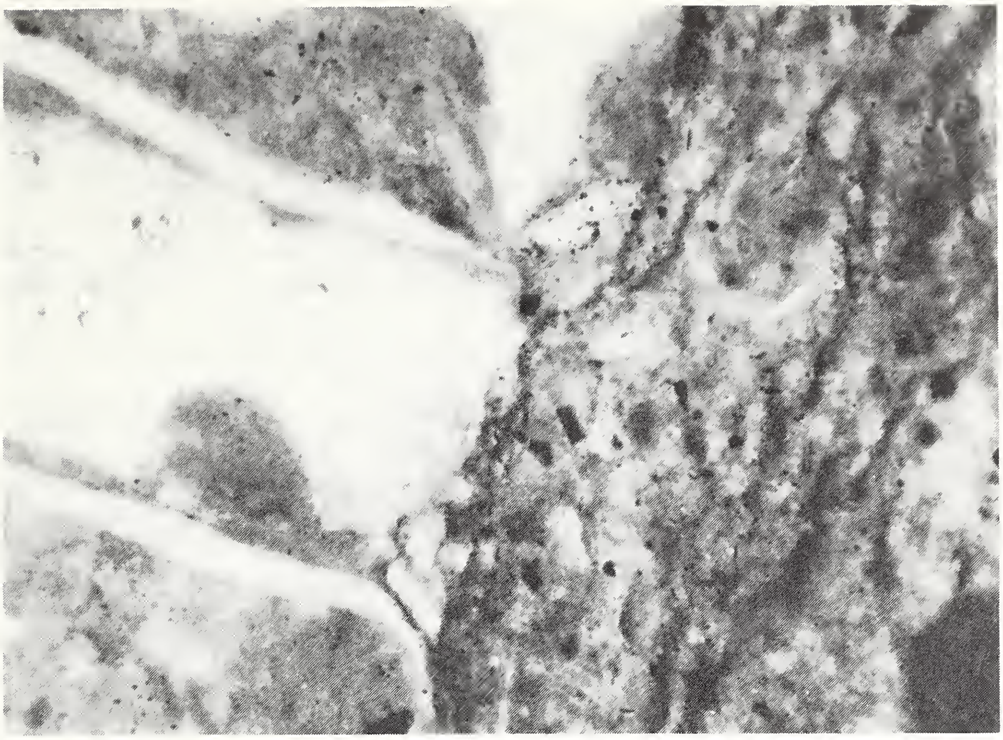

Figure. Encrusting algal mat material (left) in direct, perpendicular contact with large (by comparison) tubes of *Tetradium* (right). In the algal material, note apparent degeneration of irregular, tube-like structures to micrite. X75.

sediments (7, 8, 10). With specific reference to the Saluda coralline zone, it appears that algae played an important role (co-significance along with corals) in its structural establishment, in its persistence as an entity in the face of turbulence, and in genesis of the observed high percentage of contained micrite. The unexpected abundance of micrite in the coralline zone thus relates directly to the importance of algae in construction of the zone.

Conclusions

An unexpectedly large amount of what is apparently autochthonous micrite occurs within the coralline (*Tetradium*) biostrome of the Saluda Formation. Evidence accrued in this investigation supports the hypothesis that this *in situ* micrite was derived in the main from algal mats, through a process of grain diminution of calcareous algal tubes. Rather than simply representing a coral rubble shoal, this biostrome is the remnant of a coral/algal complex within which fragments of other types of fossils (e.g., Ostracodes) were frequently trapped. Encrusting, trepostomous Bryozoa perhaps constituted a minor component of the biostrome.

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