SHALLOW SHELF ENVIRONMENTS REPRESENTED IN MISSISSIPPIAN MONTEAGLE LIMESTONE NEAR HALETOWN, TENNESSEE

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ABSTRACT
Carbonate rock units were studied in a roadcut of Mississippian Monteagle Limestone along Interstate 24 near the exit to Jasper, Tennessee. Stratigraphic units were examined for geometry, large- and small-scale bed forms, texture and composition with the view of developing a sedimentational model.

Nineteen stratigraphic units were described and seven ancient environments were recognized: (1) Oolite Shoals, (2) Tidal Flats, (3) Mud Banks, (4) Shallow Catchment Basins, (5) Subtidal Skeletal Sands, (6) Coral Patch Reefs, and (7) Near-Shore Growths of Bryozoans, Crinoids (?) and Sponges (?).

Presumably, the oolite shoals represent Mississippian shelf-margin deposits. The remaining sediments likely represent interior shelf deposits.

INTRODUCTION
Carbonate rock units were studied in a roadcut of the Mississippian Monteagle Limestone along Interstate 24 near the exit to Jasper, Tennessee (Sewatchie quadrangle, Fig. 1). Units were examined for geometry, large- and small-scale bed forms, texture and composition with the view of developing a sedimentational model.

Work by Bergenback, Horne, and Inden (1972) near Monteagle, Tennessee suggests that the Monteagle Limestone was deposited in shoal and interior-platform environments similar to the oolitic marine sand belts and tidal bar belts along the western edge of the modern Bahamian Platform (Ball, 1967).

FIG. 1: Location of Monteagle Limestone exposure along I-24.

FIG. 2: Stratigraphic nomenclature of Mississippian System in Southeast Tennessee.

Pennington Formation
Bangor Limestone
Hartselle Formation
Monteagle Limestone
St. Louis Limestone
Warsaw Limestone
Fort Payne Formation

Thomas (1967) studied subsurface Mississippian rocks in northern Alabama (Fig. 3) and suggested a stratigraphic classification based on the premise that carbonates accumulated on a shallow marine platform adjacent to a basin filled with fine clastics (Fig. 4).

McLemore (1971) worked on surface exposures of the Mississippian System in northern Georgia (Fig. 3) and developed a similar stratigraphic classification and sedimentational model (Fig. 4) as Thomas (1967).
Seven depositional environments have been recognized among the nineteen stratigraphic units: (1) oolite shoals, (2) tidal flats, (3) mud banks, (4) shallow catchment basins, (5) subtidal skeletal sands, (6) patch reefs of coral, and (7) near-shore growths of bryozoans, crinoids (7) and sponges (7).

Oolite Shoals (Depositional Environment 1)

Low angle shoals of oolites and coarse-grained echinoderm debris that belong to depositional environment 1 are shown in Fig. 7.

Microscope study of these rocks reveals dolomitized micrite that grades laterally to dolomitized bioclast, pelmircite, pelosparr and biopareite. Ellipsoid micrite pellets ranging from 20-50 microns in long dimension, scattered oolites and local accumulations of fine- to medium-grained quartz are present in these facies.

Birdseye structures, both megascopic and microscopic, are associated with pelosparr. Fine pebble-sized crinoidal debris is present in biomircrite and biopareite. Fossil debris includes echinoderm, ostracod, brachiopod, gastropod and endothyrid fragments. The more microtic units are extensively dolomitized by anhydrid to euhedral dolomite rhombas that range from 10-200 microns along the rhomb diagonal.

The entire thickness of the lower unit (Fig. 6) is not obtainable here, but its maximum observed thickness is approximately 4 feet.

These limestone consist largely of laminated, medium- gray calcarenite with vertical burrows, thin, green shale layers and vari-shaped light-gray chert masses; plus a black chert layer that is approximately 1 inch thick and several feet long.

Biodermite, packed biopareite and biopareite with echinoderm, bryozoan, ostracod, endothyrid and spicules debris typify these facies. Note that these rocks are not dolomitized.

Thus birdseye structures, extensive dolomitization and mudcracks, associated with the upper units (Fig. 6), suggest accumulation in a high intertidal zone; by contrast, the lack of dolomitization and the presence of thin, green shale layers may indicate that the lower unit (Fig. 6) formed in a low intertidal to high subtidal area.

Fig. 5 is an artist's sketch of the I-24 roadcut exposure of Mississippian Montague Limestone along the west-bound lane of Interstate 24, west of Lake Nickajack in Tennessee (Fig. 1). The geometry, bed forms and rock types for each unit are indicated in Figs. 7-13. Thin section point count estimates (100 points per slide) not only enable determination of texture and composition but also gave an indication of constituent amounts. Point count data on selected samples are in the appendix.

Samples 2-5 are packed oomparites with superficial and mature oolites plus lesser echinoderm, brachiopod, trilobite, ostracod, gastropod, endothyrid and coral debris, much of which serves as oolite nuclei. Many oolites are cements, and others show disrupted rims, which may suggest that the rims were not completely lithified before compaction and cementation.

The upper porion of depositional environment 1 consists of dark grayish-green calcarenite that is rippled and contains lined, rip-up clasts. Further, this layer rests sharply (perhaps a sharp surface?) on underlying oolitic material.

Sample 6 is a biomircrite with rip-up clasts of oomparite, biopareite, biopareite, and micrite. Coarse-grained, angular quartz and chert grains plus fine-grained angular quartz are associated with lined echinoderm and bryozoan debris, all of which is set in a micrite matrix.

Deposition in environment 1 is probably part of an oolite shoal complex that is overlain by a thin, but widespread, storm deposit.

Tidal Flats (Depositional Environment 2)

Depositional environment 2 (Figs. 7, 8, 9, 13 & 13) deposits, interpreted as tidalites, are situated in the upper and lower portions of this roadcut exposure of Montague Limestone (Fig. 6).

The upper units consist of medium- to dark-gray calcarenite that is rippled, laminated and crossbedded plus medium- to dark-gray, yellow-weathering calcarenite with birdseye structures, vertical burrows, gray-green shale laminae and partially formed mud cracks.

Fig. 8 is a sketch of a portion of depositional environment 2.
Shallow Shelf Environments Represented in Monticello Limestone

The origin of chert in the Monticello Limestone poses questions that are very difficult to answer. Was silica chemically precipitated as gel-like masses penecontemporaneously with deposition of carbonate sediment? Was silica in solution, or was it in the form of colloids, and was it redistributed during lithification and diagenesis? Did silica in solution in groundwater move through fractures in lithified carbonates and partially replace carbonate rock?

It would seem that post-lithification silica (chert) replacement of carbonate rock from silica-charged groundwater should show a relationship to the permeable areas (fractures) within the rock mass. No unequivocal relationship of this nature was observed in the Monticello Limestone outcrops.

The unusually high concentration of vari-sized and vesi-shaped chert masses in lower 19 carbonate rock layers would seem to favor silica accumulation, enrichment, or concentration early in the history of the rock. Further, there are isolated, or scattered, examples of bedding planes, or laminae, that appear to “bend around” individual chert masses—suggesting soft sediment deformation or compaction over a mass of silica gel. Apparently, some of these masses were present during sedimentation of these carbonates.

A thin section of Sample 1, from the upper layer of depositional environment 4 (Fig. 10), shows that silica is restricted to a fragment of Ruginona coral. Certain coralline chalcedony is lined with quartz crystals that penetrate pore-filling spar crystals located in the chamber center. This may represent two generations of void-filling. Other chambers in the coralline are completely filled with pore-filling spar or microcrystalline quartz. No unequivocal evidence for reciprocal replacement of quartz and calcite was observed; therefore, it is suggested that features observed indicate pore-filling by quartz or spar penecontemporaneously with sedimentation.

Presumably, these sediments from the upper layer of depositional environment 4 are largely high subtidal, possibly back-bar, where vari-shaped silica gels and coral fragments were trapped behind low skeletal sand banks or bars and deposited in soft mud. These marine waters, enriched in silica, enabled pore-filling of coralline chambers by quartz.

The morphology of the lower layer of depositional environment 4 is shown in Fig. 11. Abundant light-gray, vari-shaped chert nodules (between 2 and 4 inches in maximum dimension) are set in a matrix of light-gray calcite and chalcedony. This unit has undulating lower and upper surfaces and ranges up to 1.5 feet thick. Carbonate rocks of this layer are composed of spicle- and bryozoan fragment-rich biomicrite and mierite with lesser echinoderm and gastropod debris.

This lower layer of depositional environment 4 was probably a shallow, subtidal catchment basin situated behind a shoal, or bar, where lime mud, sponge (7), spicules, bryozoan and chironomid (10) fragments and silica gels (later to become chert) accumulated.

Subtidal Skeletal Sands (Depositional Environment 5)

Depositional environment 5 (Figs. 6, 11 & 12) likely represents ancient skeletal sand shoals, bars or banks associated with mud banks, catchment basins and patch reefs.

Three closely-spaced layers make up depositional environment 5:

The uppermost layer forms a thin (6-10 inches, Fig. 11), light-gray eastward-dipping bed of calcilute and calcarenite. East of the mapped area on Fig. 12, it thickens to 1 1/2 feet, weathers yellowish-gray and is composed largely of calcilute. Westward it thickens to almost 5 feet.

The rocks of the upper layer range in composition from extremely dolomitized fossiliferous micrite and biomicrite, to bryozooan-rich biocomtrite with lesser brachiopod, spicule, echinoderm, ostracod and endothyrid fragments.

It is likely that these sediments in the upper layer of depositional environment 5 are low intertidal to high subtidal and may have formed as part of a mud bank that graded laterally into a winnowed, subtidal skeletal sand bank with prolific bryozoan growths.

The middle layer of depositional environment 5 (Figs. 6, 11 & 12) ranges up to 5 feet thick, and is bounded sharply by undulating lower and upper surfaces. It is composed of light-to-medium-gray, interbedded...
fossiliferous calciturbite and calcarenite. Most of the calcarenite (w) is fenestral and bioclastic. Most of these sediments are bioparticle-rich in echinoderrn grains with bryozooan, spicule, and brachiopod fragments in smaller amounts, and it is likely that these rocks were formed as subtidal sand bars with abundant clinoidal (7) growths.

Note that the upper layer of depositional environment 5 (depositional environment 6) is composed largely of a bryozoan-rich bioparticle and likely was laterally contiguous during deposition of these carbonate layers.

Near-Shore Growth of Bryozoans, Crinoids (7) and Sponges (7) (Depositional Environment 7)

Depositional environment 7 consists of four limestone layers situated near the base of this readout of Monticello Limestone (Fig. 5, pages 41-44). The upper two layers are thickest, and both the lower two layers are narrow and range up to 3 feet thick and wedge out on deposits of Unit 3. These rocks are composed of medium- to dark-gray calcarenite and calciturbite with scattered light-gray spheroidal fragments up to 3 inches in diameter. Packed bioparticle rich in echinoderm, bryozoan, and endothyrid debris with lesser spicle and ostracod fragments plus pellet-rich bioclasts and micrite characterizes this portion of depositional environment 7. Micritic form the "cement", and there is incipient dolomitization of micrite (and interstitial bioclast) by scattered dolomite rhombs

Presumably, rocks are largely bioclastic with local and bryozoan, calciturbate (7) and sponge (7) growths. Where they wedge out on Unit 3, they are likely low intertidal.

SUMMARY AND CONCLUSIONS

Interpretations of Units 1-7 are summarized on Table 1.

TABLE 1: Paleoenvironmental Summary

<table>
<thead>
<tr>
<th>Depositional Environment</th>
<th>Unit Number</th>
</tr>
</thead>
<tbody>
<tr>
<td>Oolite Shoals</td>
<td>1</td>
</tr>
<tr>
<td>Tidal Flats</td>
<td>2</td>
</tr>
<tr>
<td>Mud Banks</td>
<td>3</td>
</tr>
<tr>
<td>Shallow Catchment Basins</td>
<td>4</td>
</tr>
<tr>
<td>Subtidal Subaqueous</td>
<td>5</td>
</tr>
<tr>
<td>Patch Reef Corals</td>
<td>6</td>
</tr>
<tr>
<td>Near-Shore Growth of Bryozoans, Crinoids (7) and Sponges (7)</td>
<td>7</td>
</tr>
</tbody>
</table>

The Mississippiian Monticello Limestone probably accumulated in shallow shelf seas as suggested by Thomas (1967) and McElmoire (1971). Fig. 4.

Fig. 14 is a shallow shelf model of an ancient paleogeographic environment on Figs. 18-19.

LITERATURE CITED


