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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 (Sequatchie 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).

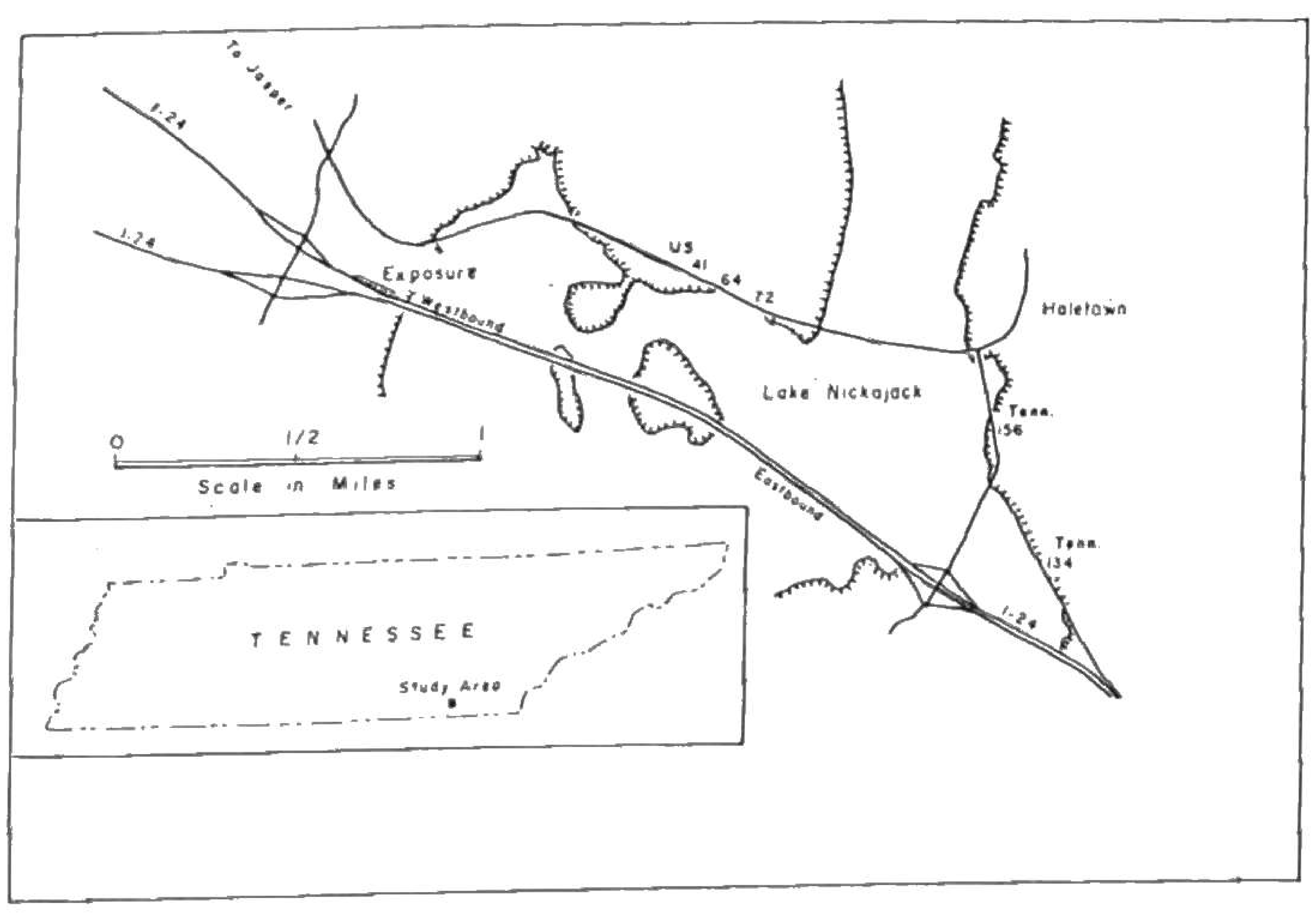

FIG. 1: *Location of Monteagle Limestone exposure along I-24.*

STRATIGRAPHY

The stratigraphy of the area was described by Milici and others (1972) on the geologic map of the Ketner Gap quadrangle (Fig. 2).

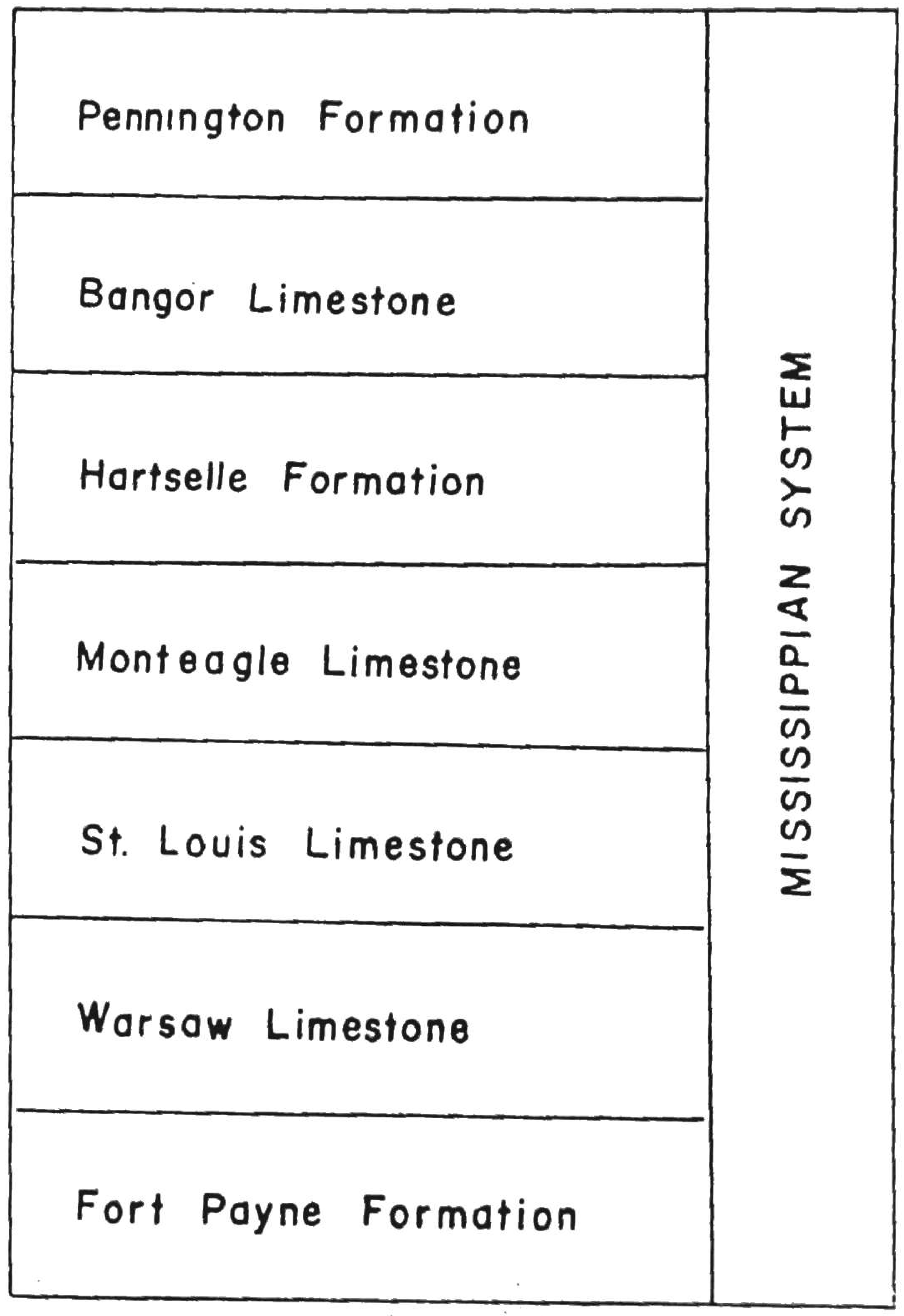

FIG. 2: *Stratigraphic nomenclature of Mississippian System in Southeast Tennessee.*

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).

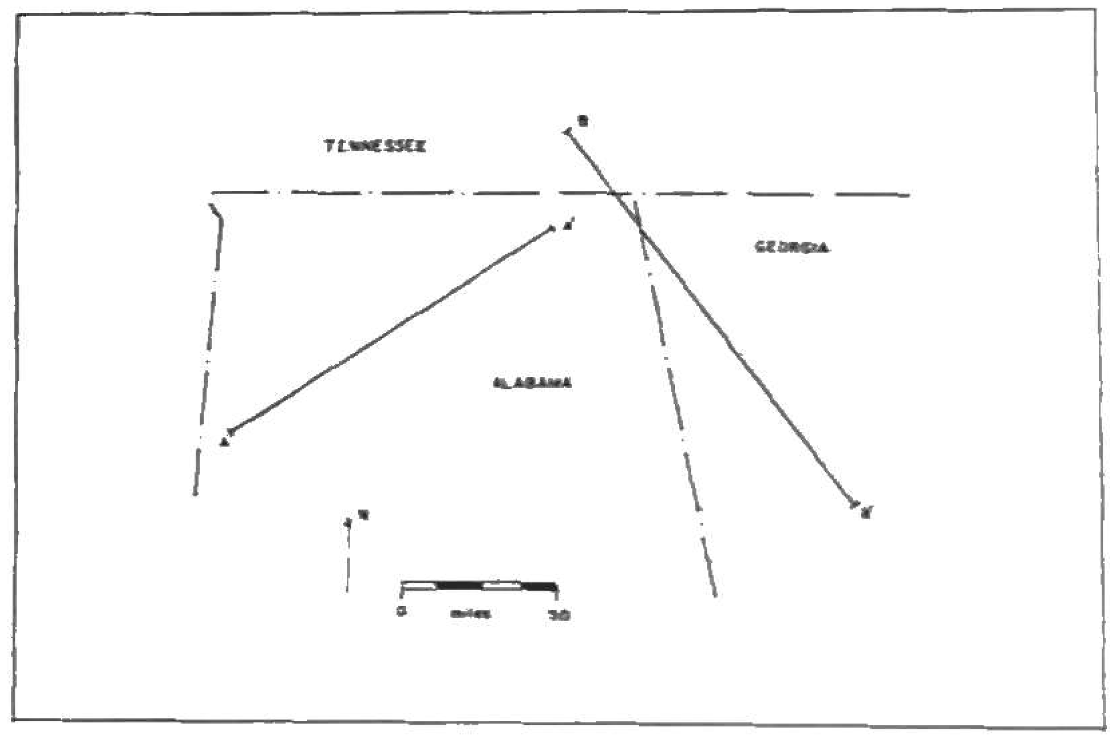

FIG. 3: *Location of stratigraphic cross-sections, Thomas (1967) and McLeMore (1971).*

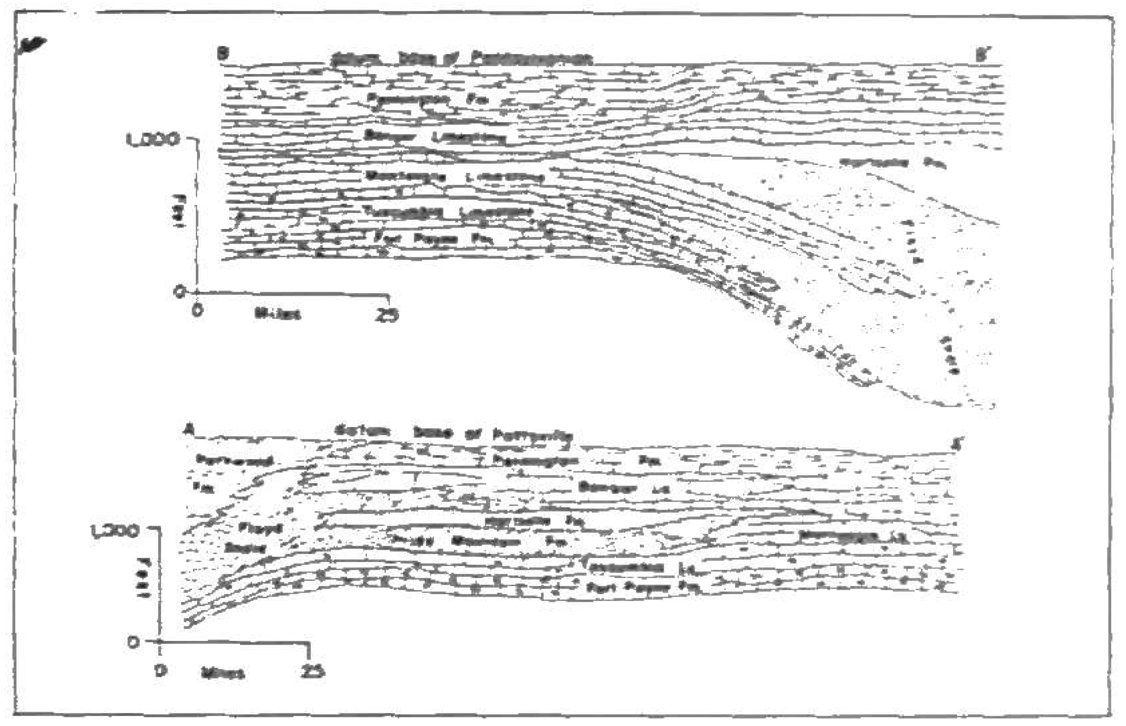

FIG. 4: *Stratigraphic cross-sections: A-A' after Thomas (1967); B-B' after McLemore (1971).*

Fig. 5 is an artist's sketch of the I-24 roadcut exposure of Mississippian Monteagle Limestone showing those portions (Figs. 7-13) that were studied in detail. Stations 1-6 are indicated on Fig. 5 to facilitate location of Figs. 7-13. Note that these carbonate rocks dip to the east at approximately 14 degrees.

Fig. 6 is a generalized stratigraphic section of this outcrop indicating major stratigraphic units with their distinguishing characteristics.

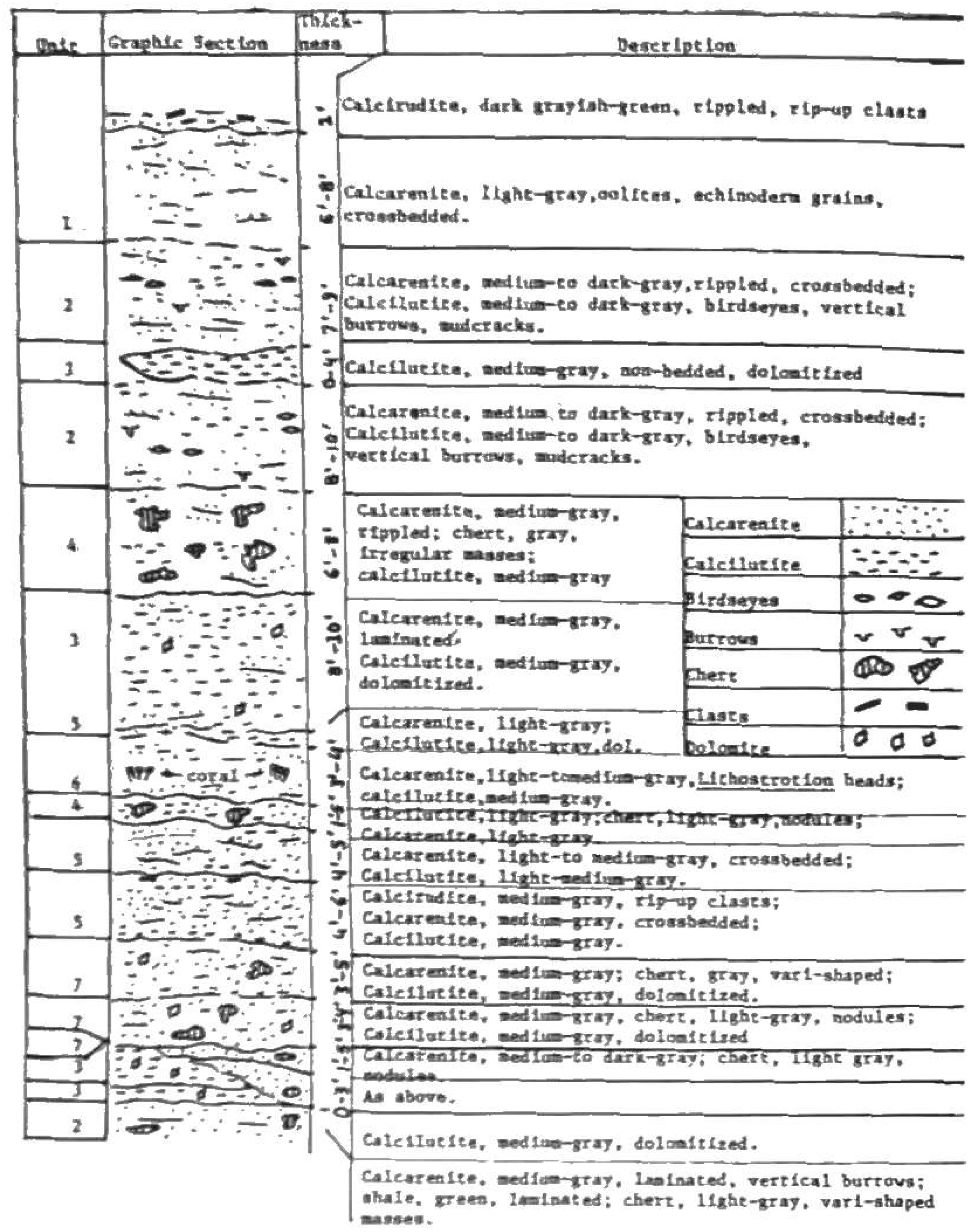

FIG. 6: *Generalized stratigraphic section of Mississippian Limestone along I-24, Tennessee .*

DISCUSSION

Nineteen stratigraphic units have been identified by detailed mapping of a roadcut exposure of Mississippian Monteagle 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 enabled determination of texture and composition but also gave an indication of constituent amounts. Point count data on selected samples are in the appendix.

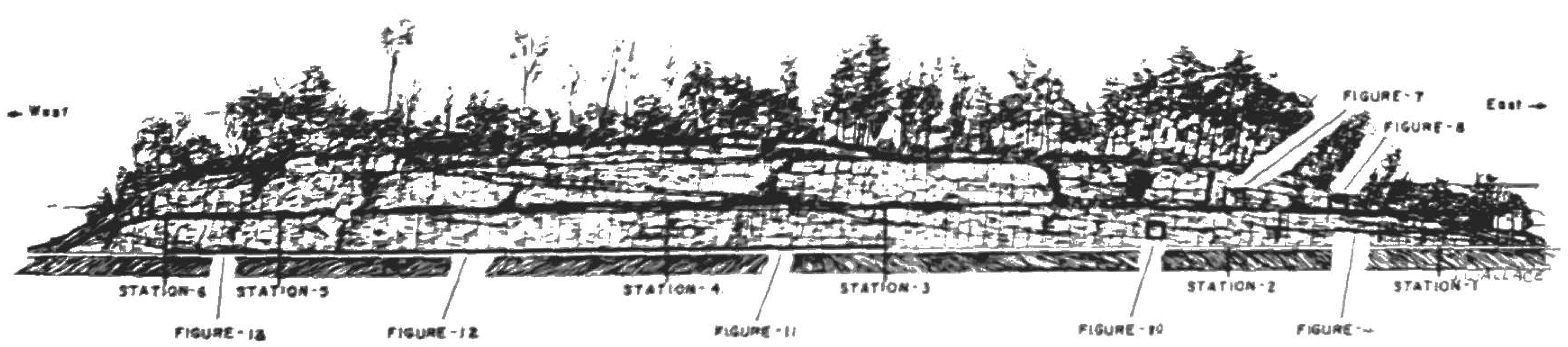

FIG. 5: *Sketch of roadcut exposure of Monteagle Limestone along westbound lane of I-24.*

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 (?) and sponges (?).

Oolite Shoals (Depositional Environment 1)

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

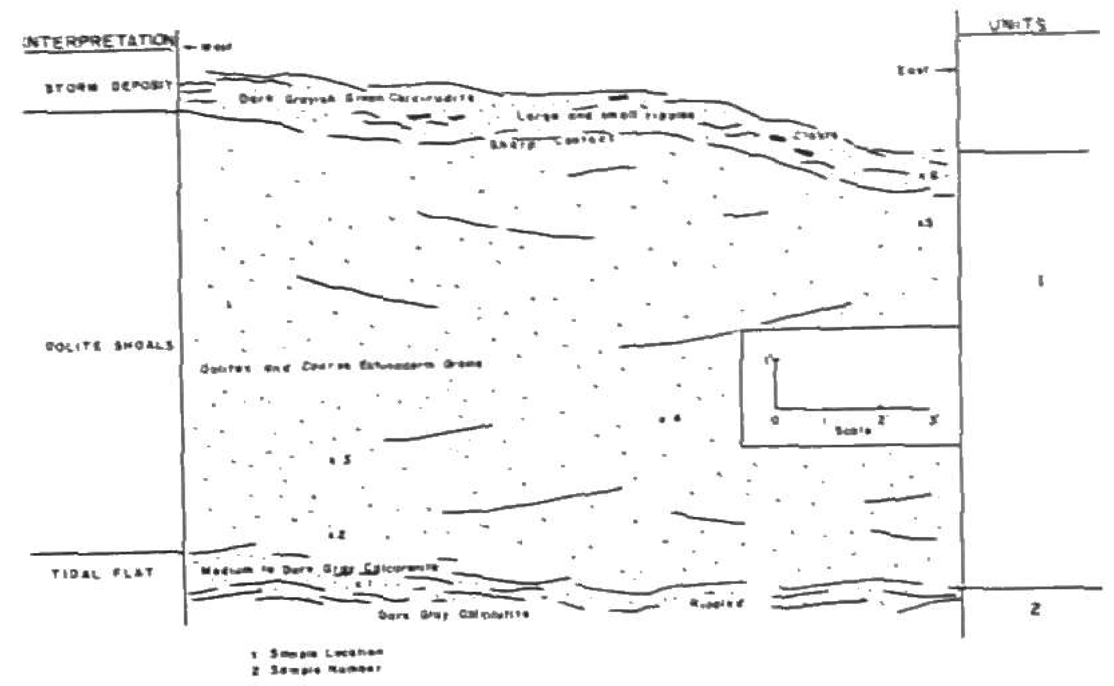

FIG. 7: *Sketch of a portion of Depositional Environments 1 and 2. (See Fig. 5 for location.)*

Samples 2-5 are packed oosparites 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 cerebroid, and others show disrupted rims, which may suggest that the rims were not completely lithified before compaction and cementation.

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

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

Depositional 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) deposits, interpreted as tidalites, are situated in the upper and lower portions of this roadcut exposure of Monteagle 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 calcilutite with birdseye structures, vertical burrows, gray-green shale laminae and partially formed mud cracks.

Microscope study of these rocks reveals dolomitized micrite that grades laterally to dolomitized biomicrite, pelmicrite, pelsparite and biosparite. Ellipsoidal micrite pellets ranging from 20-90 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 pelsparite. Fine pebble-sized crinoidal debris is present in biomicrite and biosparite. Fossil debris includes echinoderm, ostracod, brachiopod, gastropod and endothyrid fragments. The more micritic units are extensively dolomitized by anhedral to euhedral dolomite rhombs 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 limestones 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.

Biomicrite, packed biosparite and biopelsparite with echinoderm, bryozoan, ostracod, endothyrid and spicule debris typify this 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.

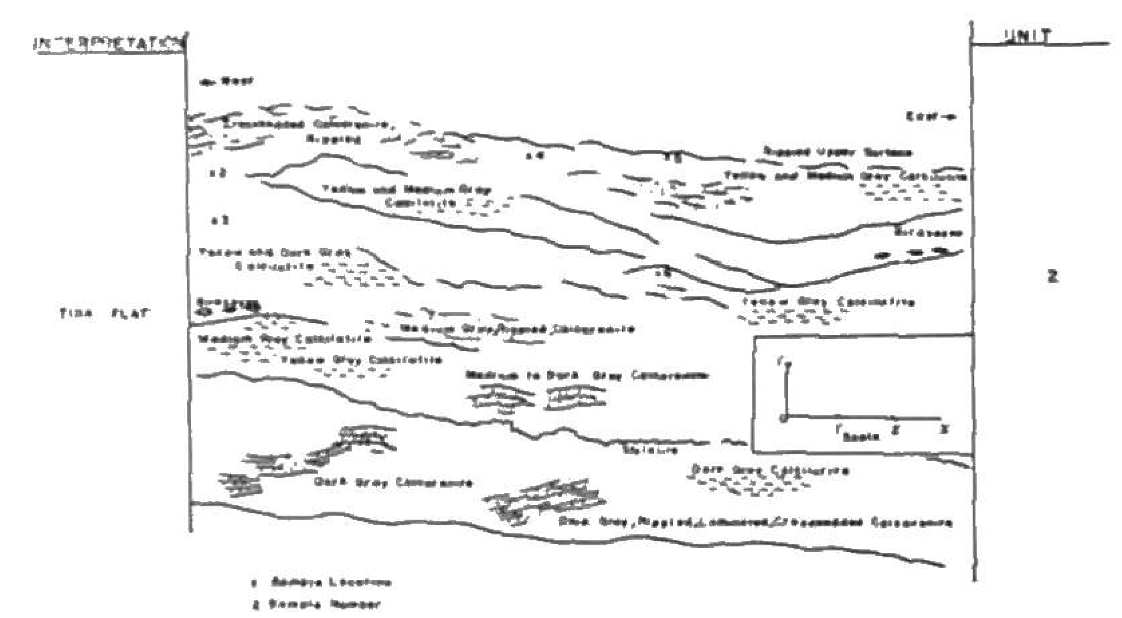

FIG. 8: *Sketch of a portion of Depositional Environment 2.*

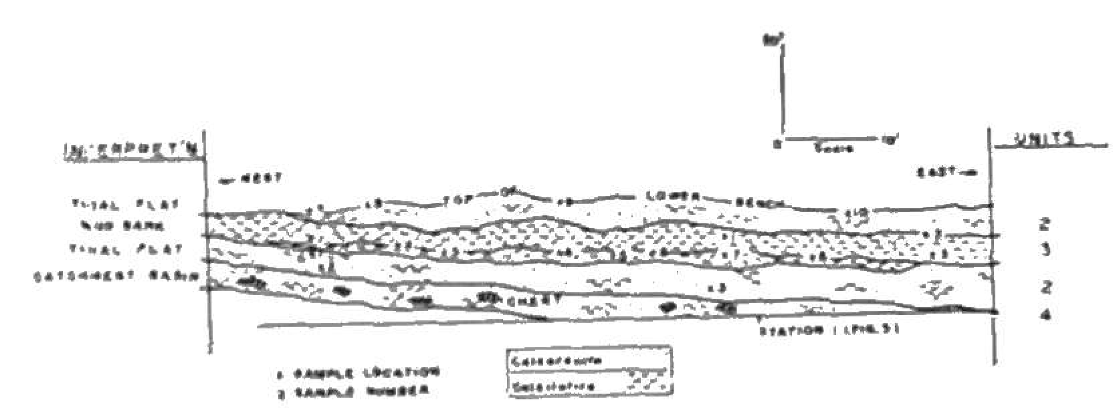

FIG. 9: *Geometry of part of Depositional Environment 2-4.*

Mud Banks (Depositional Environment 3)

Nonbedded, medium-gray, yellowish-gray-weathering calcilutite makes up Unit 3 (Figs. 9, 11, & 13).

Exposures of depositional environment 3 are situated in the upper, middle, and lower portions (Fig. 6) of this roadcut (Fig. 5).

In the upper exposures (Fig. 9), extensive dolomitization of micrite has taken place in the form of anhedral-euhedral dolomite rhombs (rhomb diagonal, 5-200 microns). There are local accumulations (15-45%) of rounded, coarse-grained, and angular, fine-sand-sized quartz. At the east end of this upper exposure of Unit 3 there is part of a delicate, branching coral (*Syringopora*?) set in a matrix of extensively dolomitized fossiliferous micrite. Well-preserved fossils are rare, but some identifiable echinoderm, bryozoan and brachiopod fragments are present. Branching, bituminous stringers may represent incipient stylolites or algal mats.

The middle exposure of depositional environment 3 (Figs. 6 & 11) ranges between 8 and 10 feet thick, rests sharply on an underlying layer, and is composed of medium-gray fossiliferous calcilutite and laminated calcarenite. A one- to two-foot-thick layer of yellow gray-weathering calcilutite is present throughout the middle of this facies. Further, microscope analysis shows these rocks to be composed of extensively dolomitized fossiliferous micrite that contains small amounts of echinoderm, bryozoan and endothyrid fragments. Sample 1 shows euhedral dolomite rhombs (rhomb diagonals up to 120 microns) set in a mosaic of anhedral to subhedral dolomite rhombs.

The lower exposure of depositional environment 3 (Figs. 6 & 13) is shaped like a mud bank and consists of almost completely dolomitized micrite with scattered, fine-grained angular quartz grains and coarse spar patches (pseudospar?) that may represent reorganized fossil debris. Sample 5 is an incipiently dolomitized packed pelbiomicrite with coarse-grained endothyrid, echinoderm, ostracod and coral (*Lithostration*?) fragments plus abundant micrite pellets. The eastern portion of this lower exposure is partly dolomitized and pellet-rich with coarse-grained, pore-filled endothyrid tests and coral fragments plus lesser echinoderm, ostrocod, spicule and superficial oolite grains. Westward, it consists of extensively dolomitized micrite.

Limestones of depositional environment 3 show undulating lower and upper surfaces. Their lateral dimension exceeds their vertical dimension and they have a lens-like, or mound-like, morphology. In addition, they are composed of extensively dolomitized calcilutite which is medium-gray when fresh and yellowish-gray when weathered.

Further, similar limestones are scattered throughout the Mississippian section ranging from the St. Louis Limestone through the Pennington Formation (Fig. 2).

Ginsburg (1956) reports modern grass-covered mud banks in the southeastern Florida Bay that are narrow, have numerous channels, and surround relatively large areas of deeper (up to 8 feet) water. These banks are periodically, subaerially exposed by wind-driven water movements.

Presumably, these modern mud banks have a low relief above adjacent sediments. Figs. 9 and 13 show that limestones from depositional environment 3 probably had a similar geometry.

However, an enigmatic question here is what enabled the lime mud deposits to attain a relief slightly higher than surrounding sediments. Was it perhaps due to a sediment-binding agent that left no trace? Modern mud banks in Florida Bay are grass-covered—doubtless, the grass serves as a sediment-binding agent—and it is likely that this grass will leave little or no trace.

Further, the extensive dolomitization of these lime mud banks that are surrounded by less dolomitized carbonate sediments may be explained by the probability that they stood with low relief above adjacent deposits and were subaerially exposed from time to time, or for much of the time, thus enabling penecontemporaneous dolomitization.

Thus, limestones of depositional environment 3 probably represent elongate, low mud banks formed by infilling of lime mud in shallow tidal channels scoured in tidal flats.

Shallow Catchment Basins (Depositional Environment 4)

These ancient environments are represented by depositional environment 4 (Figs. 6, 10 & 11), which consists of two layers—an upper and a lower unit.

Carbonate rocks of the upper layer of depositional environment 4 (Figs. 6 & 10) consist of medium-gray to yellowish-gray calcilutites (micrites), biomicrites and biosparites intimately admixed with white to gray chert masses.

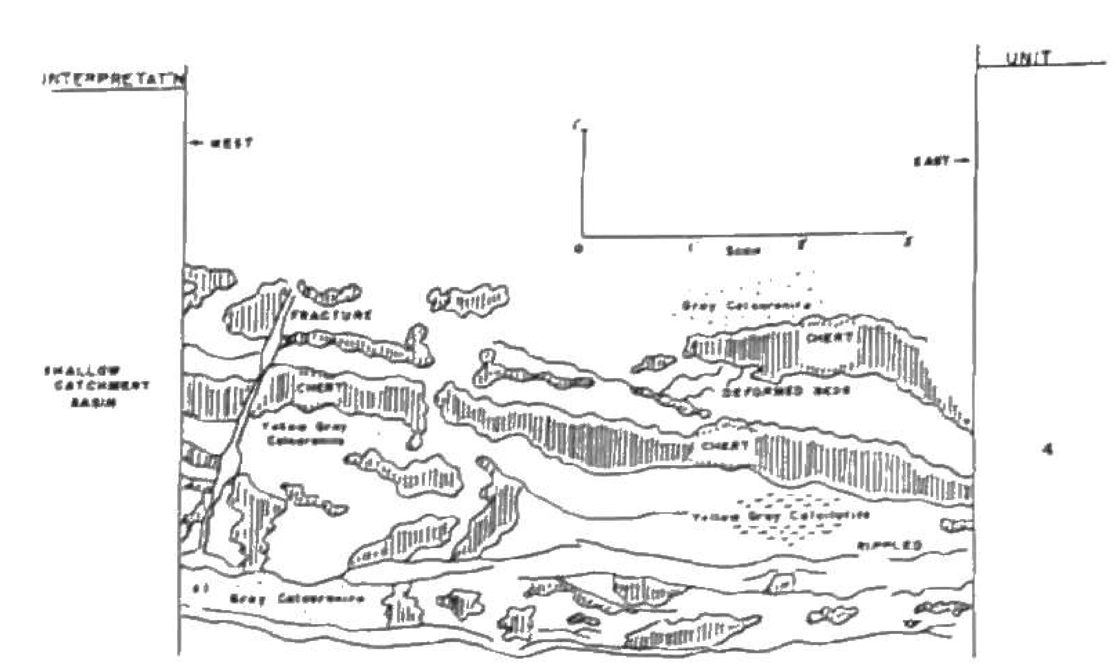

FIG. 10: *Sketch of a portion of Depositional Environment 4.*

The origin of chert in the Monteagle 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 Monteagle Limestone roadcut.

The unusually high concentration of vari-sized and vari-shaped chert masses in just 2 of 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 the chert 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 Rugosan coral. Certain corallite chambers are 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 corallite 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 corallite 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 calcilutite and calcarenite. This unit has undulating lower and upper surfaces and ranges up to 1.5 feet thick. Carbonate rocks of this layer are composed of spicule- and bryozoan fragment-rich biomicrite and micrite with lesser echinoderm and gastropod debris.

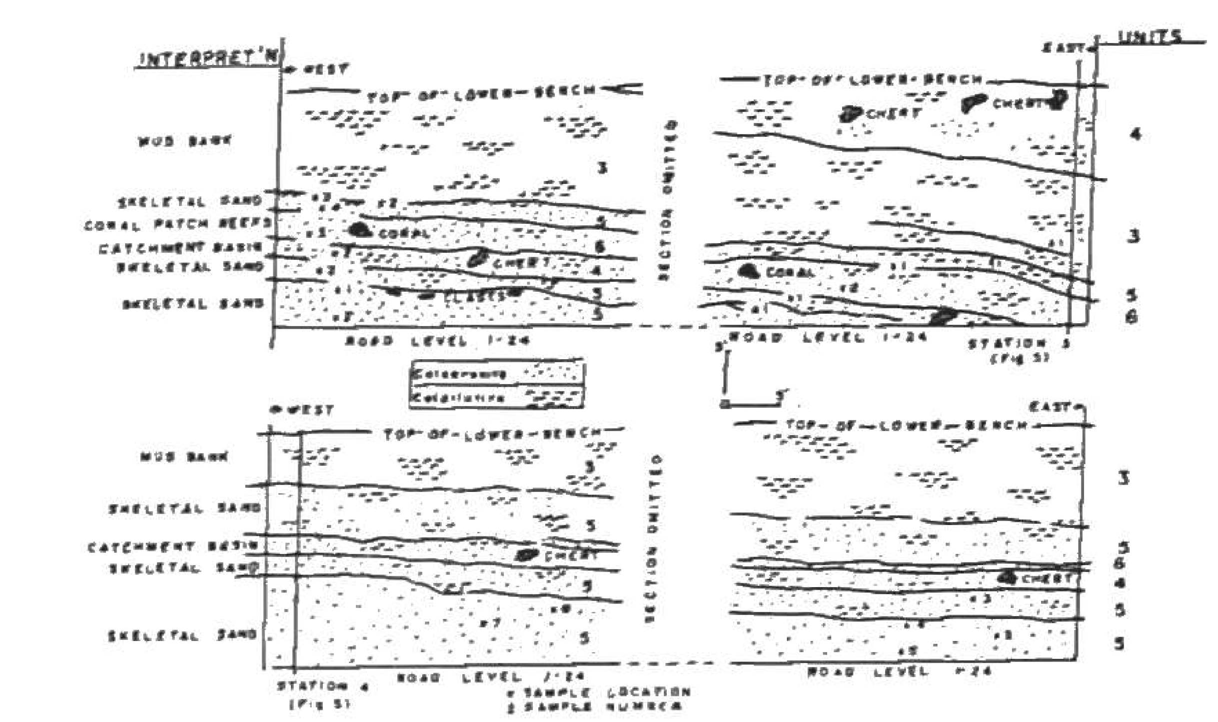

FIG. 11: *Geometry of part of Depositional Environments 3, 4-6, between stations 3 and 4.*

This lower layer of depositional environment 4 was probably a shallow, subtidal catchment basin situated behind a shoal, or bar, where lime mud, sponge (?), spicules, bryozoan and chrinoidal (?) 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, banks or bars that were 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 calcilutite and calcarenite. East of the mapped area on Fig. 12, it thickens to 1½ feet, weathers yellowish-gray and is composed largely of calcilutite. Westward it thickens to almost 5 feet.

The rocks of the upper layer range in composition from extremely dolomitized fossiliferous micrite and biomicrite, to bryozoan-rich biosparite 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 calcilutite and calcarenite. Most of the calcarenite is winnowed and crossbedded. Most of these sediments are biosparites rich in echinoderm grains with bryozoan, spicule, and brachiopod fragments in smaller amounts, and it is likely that these rocks were formed as subtidal sand bars with abundant crinoidal (?) growths.

The lower layer of depositional environment 5 (Figs. 6, 11 & 12) contains large (up to 3 by 1 inch) calcilutite (rip-up?) clasts along its upper surface; ranges from 4-6 feet thick; is delintated by a sharp, undulating lower and upper surface; has a 3-6 inch thick, light-gray layer of calcilutite resting on much of its lower surface and consists largely of medium-gray calcarenite and calcilutite. Most calcarenite in this layer is crossbedded.

Biosparite, rich in bryozoan fragments, dominates this lower layer of depositional environment 5. Brachiopods, endothyrids, and oolites occur in small amounts.

Micrite (rip-up-) clasts in the lower layers of Unit 5 may represent a storm deposit. The thin calcilutite near the base of this layer may have been a subtidal settling basin associated with a subtidal skeletal sand bank with abundant bryozoan growths.

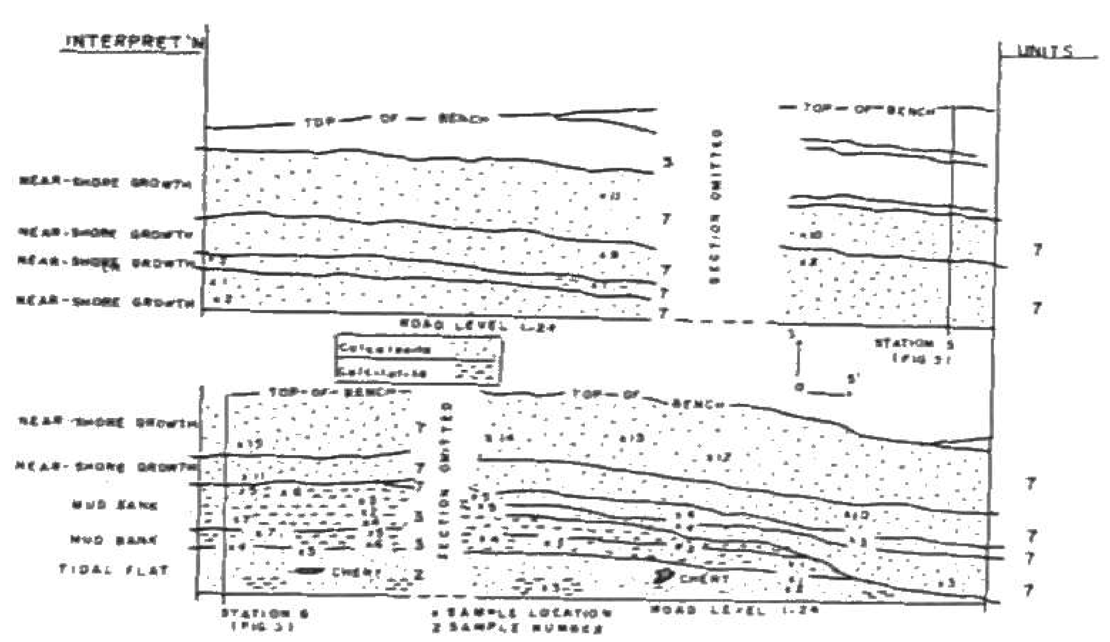

FIG. 12: *Keometry of part of Depositional Environments 3, 4-7, between stations 4 and 5.*

Patch Reefs of Coral (Depositional Environment 6)

Light-to medium-gray calcilutite and calcarenite, ranging between three and four feet thick, with toppled, cobble-sized heads of the coral *Lithostrotion canadensis* (?) characterize depositional environment 6 (Fig. 6). Figs. 11 and 12 show the geometry of this layer.

Biosparite, rich in bryozoan and spicule debris, is dominant. Brachiopod, echinoderm, endothyrid, ostracod and gastropod fragments occur in small amounts.

Small patch reefs of the coral *Lithostrotion canadensis* (?) were probably associated with a subtidal, skeletal sand bar rich in bryozoan and sponge (?) growths.

Note that the upper layer of depositional environment 5 and depositional environment 6 is composed largely of bryozoan-rich biosparite and likely was laterally contiguous during deposition of these carbonates.

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

Depositional environment 7 consists of four limestone layers situated near the base of this roadcut of Monteagle Limestone (Figs. 5, 6, 12 and 13).

The upper two layers are throughgoing, but the lower two layers wedge out against calcilutite (mud bank) deposits of Unit 3.

The upper two layers of depositional environment 7 range from 3-5 feet thick; are composed of lensing units of medium-gray calcarenite and yellowish-gray weathering calcilutite as well as light-gray, vari-shaped chert masses ranging from almost spherical (diameter from less than 1 inch to 4 inches) to elongate, discontinuous, flattened bodies that range up to 4 feet long and 1-2 inches thick.

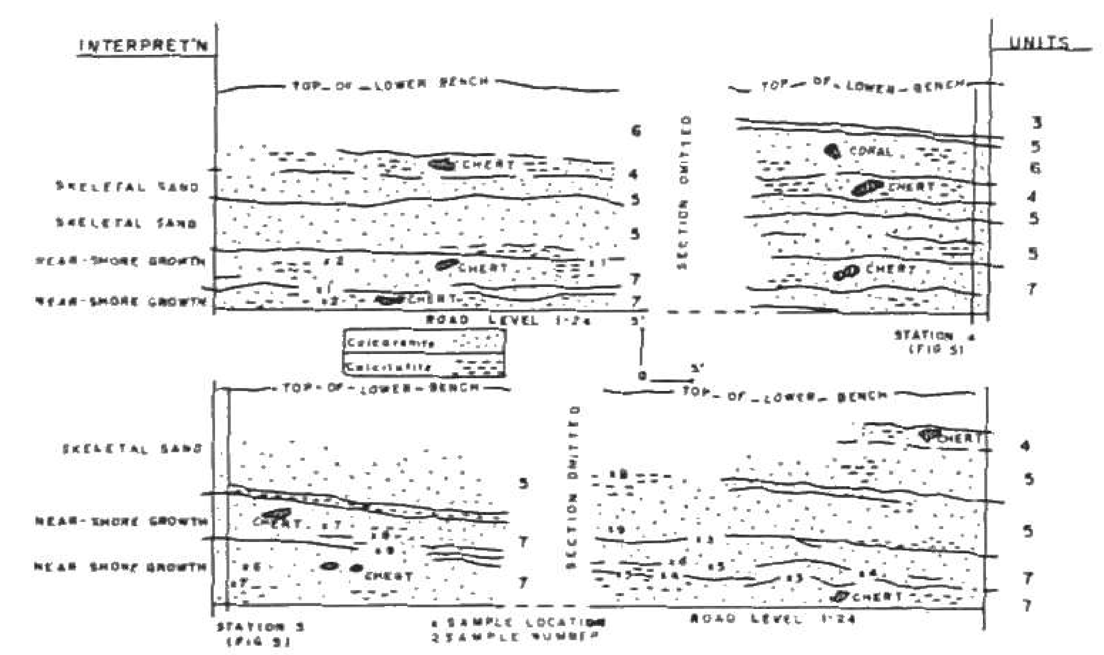

FIG. 13: *Geometry of part of Depositional Environments 2, 3 and 7, between stations 5 and 6.*

The eastern portion (Figs. 12 & 13) of these two carbonate rock layers consists of winnowed, packed biosparites and pelsparites plus packed biomicrite, all of which are rich in bryozoan, echinoderm and spicule fragments with lesser ostracod, brachiopod, endothyrid and gastropod grains plus quartz grains and superficial oolites. Incipient dolomitization in the form of scattered dolomite euhedra occurs locally. Westward, these two layers become fine-grained, are rich in micrite pellets and clasts, have local concentrations of fine-grained quartz and are partially dolomitized.

The eastern portion of these deposits may represent low skeletal banks with profuse bryozoan, sponge (?) and crinoidal (?) growths that were mostly high subtidal, but may have been infrequently exposed and dolomitized. Westward, they likely ranged up to low intertidal deposits.

The lower two layers of depositional environment 7

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 calcilutite with scattered light-gray spherical chert nodules up to 3 inches in diameter.

Packed biosparite rich in echinoderm, bryozoan, and endothyrid debris with lesser spicule and ostracod fragments plus pellet-rich biomicrite and micrite characterize this portion of depositional environment 7. Microspar forms the "cement", and there is incipient dolomitization of micrite (and interstitial micrite) by scattered dolomite euhedra.

Presumably, these rocks are largely high subtidal with localized bryozoan, crinoidal (?) and sponge (?) 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.*

Depositional Environment	*Unit Number*
Oolite Shoals	1
Tidal Flats	2
Mud Banks	3
Shallow Catchment Basins	4
Subtidal Skeletal Sands	5
Patch Reefs of Coral	6
Near-shore Growths of Bryozoans, Sponges (?) and Crinoids (?)	7

The Mississippian Monteagle Limestone probably accumulated in shallow shelf seas as suggested by Thomas (1967) and McLemore (1971), Fig. 4.

Fig. 14 is a shallow shelf model indicating the paleogeographic distribution of a number of ancient Mississippian environments.

FIG. 14: *Shallow Shelf Model of Monteagle Limestone roadcut exposure along I-24.*

Presumably, depositional environments 2-7 are composed of interior platform environments that accumulated in transgressing seas that generally moved southward. Depositional environment 1 (oolite shoals) likely represents shelf-margin deposits. It is likely that these carbonate deposits resulted from repeated shifting of an ancient strand across a shallow Mississippian shelf.

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