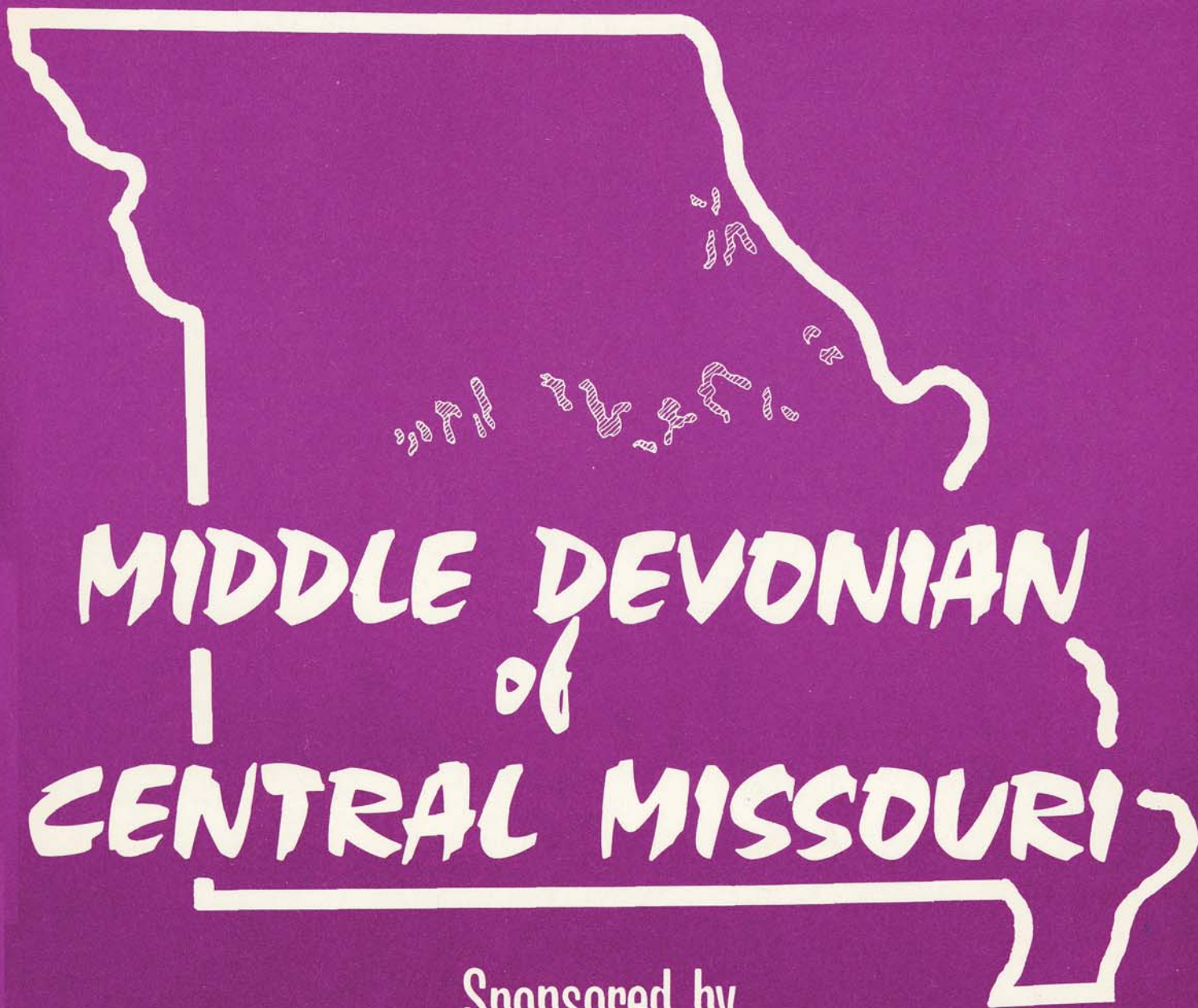


ASSOCIATION OF MISSOURI GEOLOGISTS
FOURTEENTH ANNUAL FIELD TRIP

SEPTEMBER 29-30, 1967



Sponsored by
Department of Geology
University of Missouri
Columbia, Missouri

FIELD TRIP LEADERS

George Fraunfelter

Lyle Sleeman

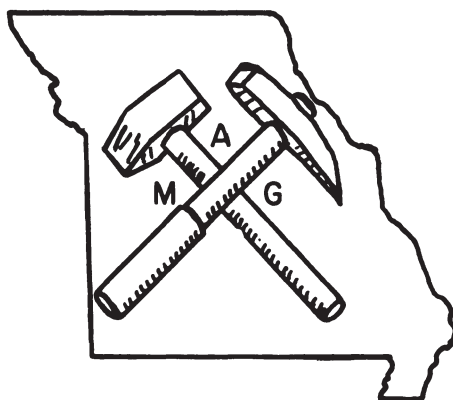
GUIDEBOOK COORDINATED AND EDITED BY

GUIDEBOOK DESIGN AND DRAFTING BY

Tom Freeman

Byram Reed

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DEDICATION

to

MAURICE GOLDSMITH MEHL

(1887-1966)

To Professor Maurice Goldsmith Mehl, whose long interest in the Devonian and Carboniferous of Missouri has stimulated these and other studies, we dedicate this work. That this particular Guidebook be dedicated to "Doc" is especially appropriate, because he will long be remembered for the inspiration and guidance that he gave to students.

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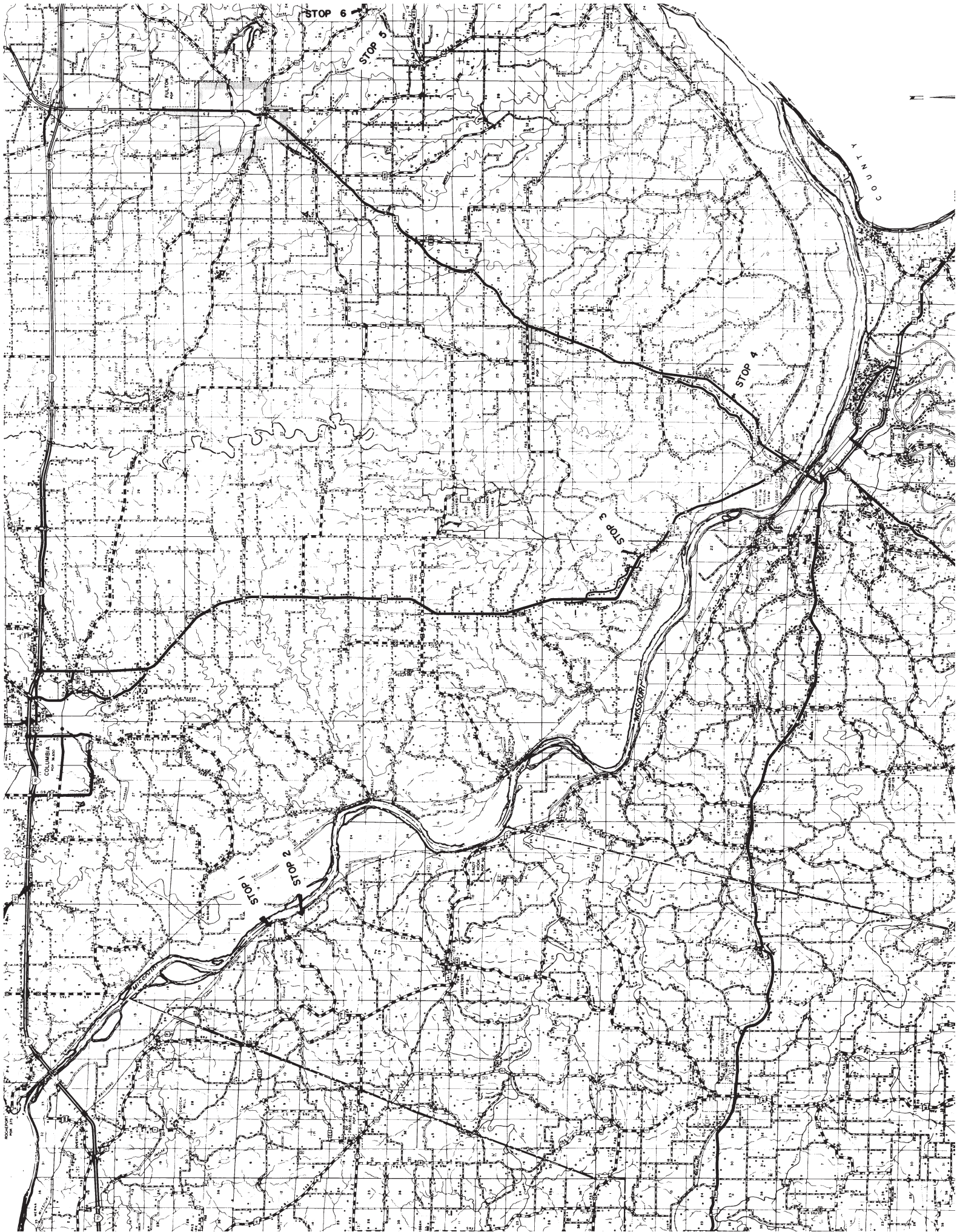
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OBJECTIVES

The objectives of this field trip are:

1. To illustrate the areal and stratigraphic distribution of the Cooper, Callaway, and Mineola "formations", and to document the facies relationships that exist among them.
2. To present for the participant's consideration a nomenclatorial revision of the Middle Devonian of central Missouri.
3. To illustrate the petrology and paleogeography of the Middle Devonian of Central Missouri.
4. To illustrate the distribution of fossils in the Middle Devonian of Central Missouri and to present correlations with rocks in adjacent states.

ACKNOWLEDGEMENTS

This Guidebook results from the work of many people. First and foremost were the early efforts of George Fraunfelter and Lyle Sleeman, who tackled the Middle Devonian of Central Missouri as dissertation problems. Fraunfelter did his work under the supervision of the late Dr. M. G. Mehl, and Sleeman studied under the direction of Dr. John Hubert. To both of these University of Missouri professors, we owe a sincere debt of gratitude.

Fraunfelter and Sleeman now teach college in separate states, and it has been Tom Freeman's task to coordinate their contributions to this Guidebook and to edit and revise their manuscripts to assure consistency of nomenclature.

Freeman's Carbonate Petrology class collected and prepared Devonian samples during the spring of 1967, and these have served as valuable guides in drafting the measured sections. The laborious task of designing and drafting this Guidebook was done by Byram Reed, graduate student and aspiring carbonate petrologist.

Dr. Clayton H. Johnson assisted Fraunfelter, Sleeman, and Reed in laying out the road log.

ON THE NOMENCLATORIAL REVISION OF THE MIDDLE
DEVONIAN OF CENTRAL MISSOURI

Tom Freeman
Department of Geology, University of Missouri, Columbia

The oldest name relevant to the Middle Devonian of central Missouri is "Cooper", which was proposed by Swallow in 1855 for "marble" in Cooper County. Not until 39 years later did Keyes coin the term "Callaway" for certain other Middle Devonian rocks in central Missouri. Still later, E. B. Branson named the Mineola formation (1924).

More recently, however, it was realized that the Cooper, Callaway, and Mineola formations occupy similar stratigraphic positions (Unklesbay, 1952 and Koenig, 1961). In short, they are facies of a common sedimentologic "package", and the problem arose: How should these formations be grouped nomenclatorially so as to communicate their mutual relationships?

If a senior synonym were to be selected, it should be "Cooper", because that term has priority of date. But, *although a stratigraphic name can be expanded or reduced in rank (ex., group, formation, member), it should not be expanded or reduced so as to include more or less rock than that previously included.* If any one of these names were expanded to include the others, either a new name would be needed to replace its earlier meaning, or an awkward homonymy would result. Instead, a *new* name should be proposed for that body of rock consisting of Cooper, Callaway, and Mineola.

Fraunfelter (M.U. dissertation, 1964) proposed the name "Cedar City formation" for this body of rock, but that name has not yet been published, and its adoption here does *not* constitute formal erection of the term.

PETROLOGY OF THE CEDAR CITY FORMATION¹

Lyle Sleeman
St. Josephs College, Rensselaer, Indiana

INTRODUCTION

The Cedar City formation is a distinct mappable unit of Middle Devonian age with a rich diversity of rock types. Throughout much of central Missouri it is the only representative of the Devonian, but in northeastern Missouri younger Devonian rocks are more prominent.

The objectives of this study were to establish through field, petrographic, and mineralogic studies, the petrogenesis of the rock types, the paleogeography, and the depositional environments reflected by the Cedar City. This field trip seems especially appropriate in the light of the vast amount of research being conducted on Recent and ancient carbonates. Many of the rock types of particular interest to carbonate petrographers are well displayed in Cedar City outcrops.

Only a small portion of the area treated in my dissertation (Fig. 2) will be examined during this field trip, but this is the area of greatest variety, and this area contains essentially all of the important rock types of the formation.

PREVIOUS WORK

Earlier work on the Cedar City was essentially paleontologic in nature. E. B. Branson, of the University of Missouri, worked and published stratigraphic and paleontologic information on the Middle Devonian of central Missouri from 1915 until the early 1940's. Limited general stratigraphic work was also done on these rocks in areas of map-theses.

Branson (1922, 1944) believed that the Middle Devonian rocks of central Missouri consisted of four formations, the Cooper, Mineola, Ashland, and Callaway. Branson (1944, p. 174) believed that "the oldest formations are Cooper in the western part of the area, and Mineola in the eastern part. Both are Middle Devonian in age. Both are overlain in places by patches of the Ashland limestone of Middle Devonian age and by the Callaway limestone of uppermost Middle Devonian." The bases for these separate formations were in part geographic and in part lithologic and paleontologic.

¹Editor's note: Sleeman's dissertation (1964) referred to the Callaway Formation, but for reasons outlined on page 4 and for consistency in this guidebook, it is referred to here as the Cedar City formation.

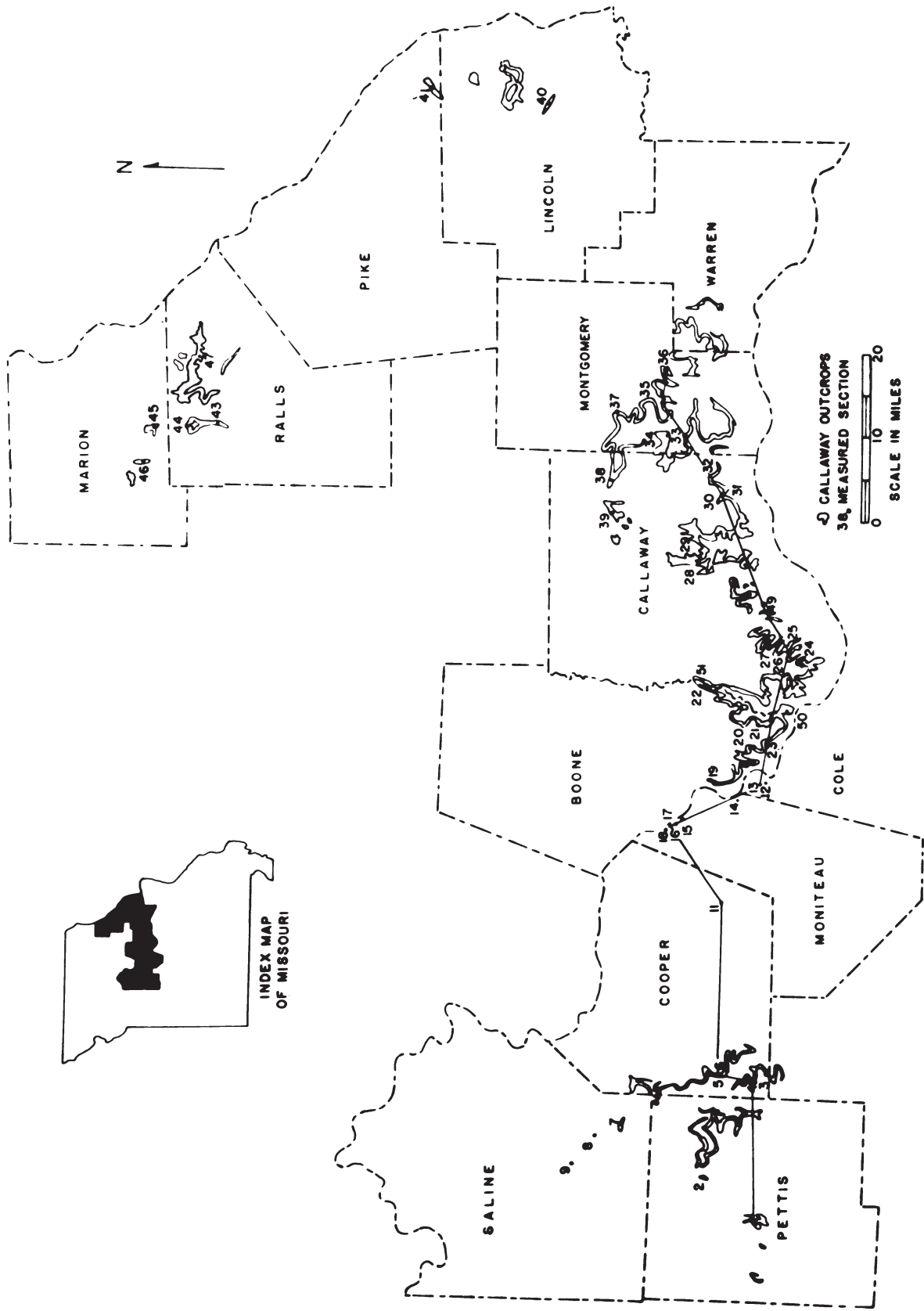


Figure 2. - Outcrop pattern of Middle Devonian rocks in the area studied by Sleeman (1964) and Fraunfelter (1964). Line of section is that of figure 3.

STRATIGRAPHY

The Cedar City formation includes the entire sequence of Middle Devonian rocks in central Missouri. Ordovician rocks underlie these rocks throughout the outcrop belt except locally in the northeast where Silurian rocks occur. The oldest Ordovician formation overlain by the Cedar City is the Jefferson City Dolomite of Canadian age. Eastward and northeastward Ordovician rocks are progressively younger. The youngest Ordovician formation underlying the Cedar City is the Maquoketa Shale of Cincinnati age.

In central and northeastern Missouri Upper Devonian rocks overlie the Cedar City with a questionable unconformity. Where Upper Devonian rocks are absent, the Cedar City is commonly overlain unconformably by either the Bushberg Sandstone or the Chouteau Limestone, both of Mississippian age.

Following the paleontological work of Fraunfelter, the age of the Cedar City is believed to be Hamilton(?) and perhaps in part Onondaga.

COOPER FACIES

The Cooper facies is best developed in the western part of the study area and interfingers with the Callaway facies to the east (Figs. 3 and 4). On first appearance the Cooper facies appears to be more or less homogeneous throughout, but detailed work reveals a variety of important rock types.

Very fine-grained rocks dominate the Cooper, with micrites (calcilutites) and dismicrites (disturbed calcilutites) making up well over 60% of the total facies (Fig. 3). The rocks are notably lacking in fossils, but at several localities fossils are locally concentrated in quantities sufficient to form biomicrites and fossiliferous intrasparites. At Stops 1 and 2 the Cooper facies is represented by intraclast-bearing carbonates and orthoquartzites. The only fossils observed at these localities are ostracodes and calcispheres.

Stop 2 is significant because the rocks are believed to represent a shoal area or marine bank. The evidence for this conclusion is that the rocks reflect high-energy environments. Interfingering of carbonates and orthoquartzites and the occurrence of dessication cracks suggest intermittent sub-aerial exposure. Intrasparites, expected to form on marine banks, occur at Stops 1 and 4. These intrasparites consist of rounded, sand-sized particles of microcrystalline calcite cemented with sparry calcite. The almost entire absence of lime mud suggests extensive winnowing.

At the Adrian Quarry (Stop 3) rocks of the Cooper facies

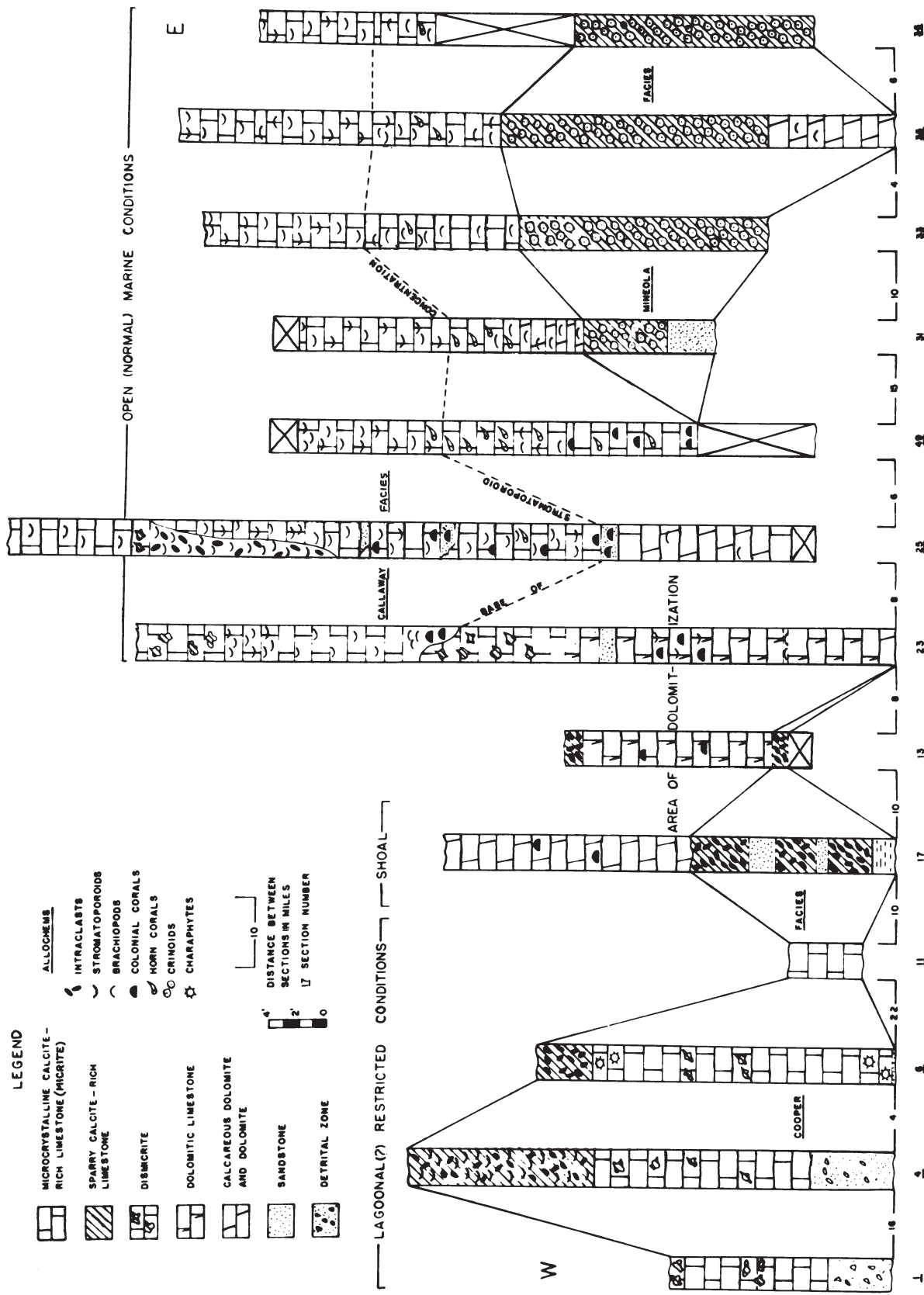


Figure 3. - West-east cross-section of the Cedar City formation. Line of section is shown in figure 2.

record lower energy environments than those observed at Stops 1 and 2. Micrites and dismicrites consist entirely of microcrystalline calcite that must have accumulated under quite water conditions. Dismicrites contain patches of sparry calcite, but the spar occupies voids that are not intergranular. Hence, winnowing and persistent current activity were minimal. The voids might have been formed by slumping, disruption by short-lived currents, burrowing organisms, gas action, expulsion of water during compaction, contraction, or processes unknown.

The preponderance of microcrystalline calcite-rich rocks (micrites) and the almost total absence of fossils over broad areas suggest that the area west of Stops 1 and 2 (Moniteau, Cooper, Pettis, and Saline Counties) was an area of quiet water and possibly restricted conditions (hypersaline or brackish). Periodic currents were sufficiently strong to form dismicrites and, more rarely, intrasparites and intramicrudites, but these currents were probably short-lived and did not significantly modify the ecology of the environment.

A hypothesis consistent with these observations suggests a lagoon- or bank-type environment on the leeward side of a peninsula or shoal in the area around Lupas. This barrier probably trended roughly northwestward (Fig. 5).

CALLAWAY FACIES

The Callaway facies includes most of the exposed Middle Devonian rocks in central Missouri. This facies is best developed in southern Boone and Callaway Counties where thicknesses of 40-55 feet are common. The obvious difference between the Callaway facies and the Cooper facies is a greater abundance of both dolomite and fossils in the Callaway.

Rocks that reflect low-energy environments comprise more than 85% of the Callaway, and rocks containing abundant fossils account for approximately 75% of the total. These rocks record environments quite different from those represented by the Cooper facies.

Perhaps the simplest way to handle the Callaway facies is to consider it in terms of its biofacies (Fraunfelter, 1964).

Space does not permit a comprehensive discussion of all the rock types in the Callaway facies but a number of important points should be made:

1. The majority of the rocks are fossil-bearing microcrystalline calcite-rich rocks suggesting open-circulation but deposition either below wave base or in environments that were quiet either because of barriers or because of the baffling

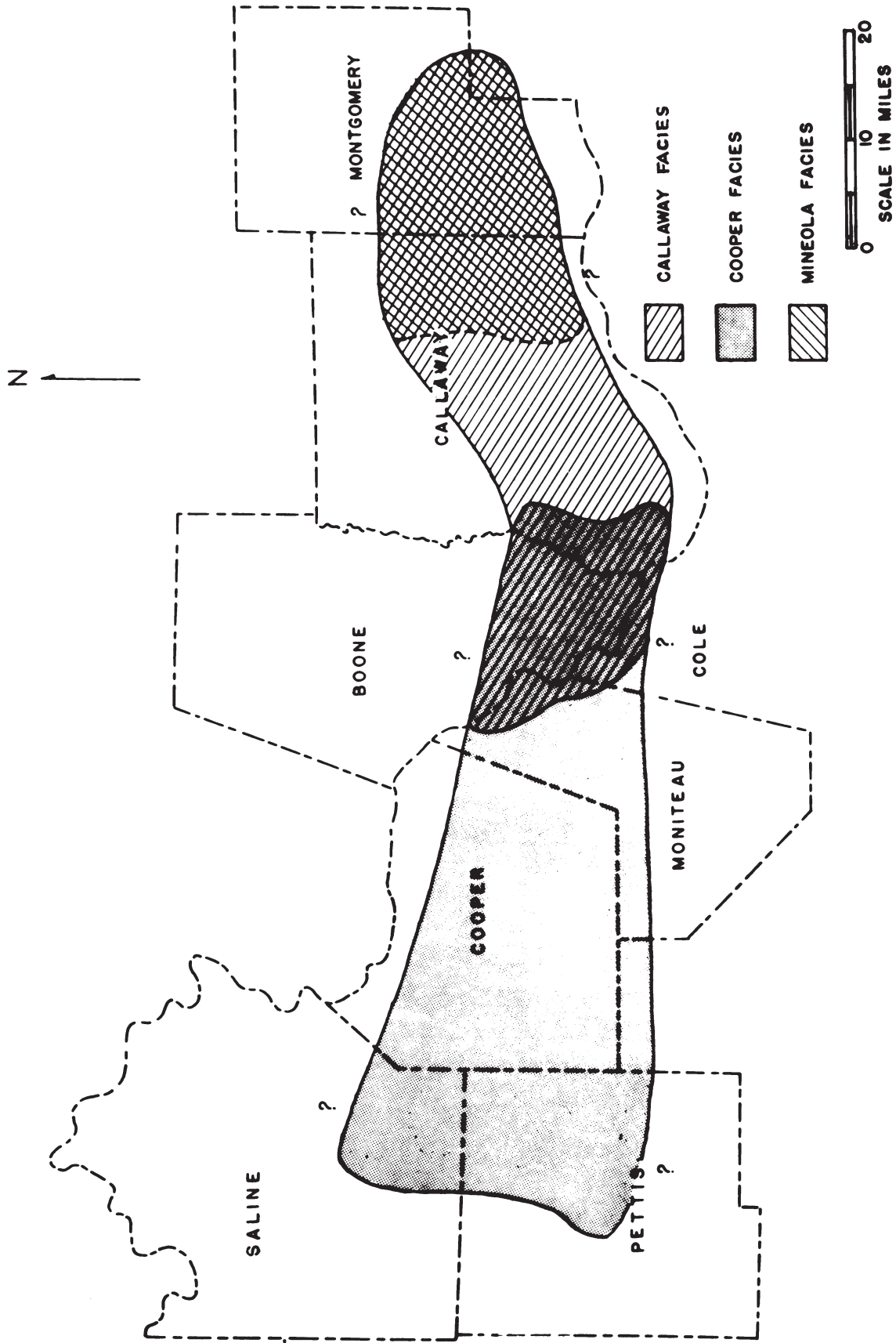


Figure 4. - Areal distribution of the Cooper, Callaway, and Mineola facies of the Cedar City formation. Superposition of the Cooper and the Callaway and superposition of the Callaway and the Mineola are shown by combined patterns. (Sleeman, 1964)

effect of bottom growth (ex.; marine grasses, masses of dendroid stromatoporoids, or other fauna and flora).

2. The *Hexagonaria profunda* biofacies zone reflects both high- and low-energy environments, as reflected by different rock types in which the corals are imbedded.

3. Large reefs were uncommon in the Callaway seas, but local incipient reef development existed at times.

4. Sediments of the *Atrypa* biofacies were more susceptible to dolomitization than were sediments of the other zones. *Atrypa* also tends to occur in biosparites more commonly than any other fossil except crinoids. The *Atrypa* biofacies is interpreted as having accumulated in water that was shallow but deeper than that reflected by the *Hexagonaria* biofacies.

5. The *Atrypa* biofacies represents an accumulation of gregarious organisms (*Atrypa*) in an environment that must have been unusual, as indicated in many areas by the abundance of *Atrypa* and the almost complete absence of other fossils.

6. The *Stropheodonta* biofacies is believed to represent a "normal" environment, possibly an open marine basin rich in a cosmopolitan fauna that included a variety of brachiopods, horn corals, gastropods, bryozoans, nautiloids, crinoids, ostracodes, foraminifers, and mat, cabbage, and dendroid stromatoporoids. The highly diverse and abundant fauna indicates an environment favorable to many forms of life, suggesting that normal marine conditions prevailed. The predominance of microcrystalline calcite indicates deposition below wave base, probably in water deeper than that in which *Atrypa* lived.

Dolomite is almost entirely absent in the *Stropheodonta* biofacies, and silt- and sand-sized terrigenous material is scarce, suggesting a basin some distance from land.

7. Stromatoporoids are particularly abundant in the uppermost part of the Callaway facies, and they locally occur through thicknesses in excess of 30 feet. Mat- and cabbage-type stromatoporoids are very common, but dendroid stromatoporoids, mainly *Stachyodes coespitosa* and *S. costulata*, are most abundant. These are generally imbedded in a microcrystalline calcite matrix. Individual fossil fragments show very little evidence of abrasion.

In southern Boone County, the stromatoporoid biofacies is thought to reflect a shallowing of the water and a return to semi-restricted conditions. Circulation was sufficient to introduce nutrients necessary for life, but it was not characterized by extensive wave action.

MINEOLA FACIES

Rocks of the Mineola facies are not well represented at any of the sections to be visited on this field trip, but they

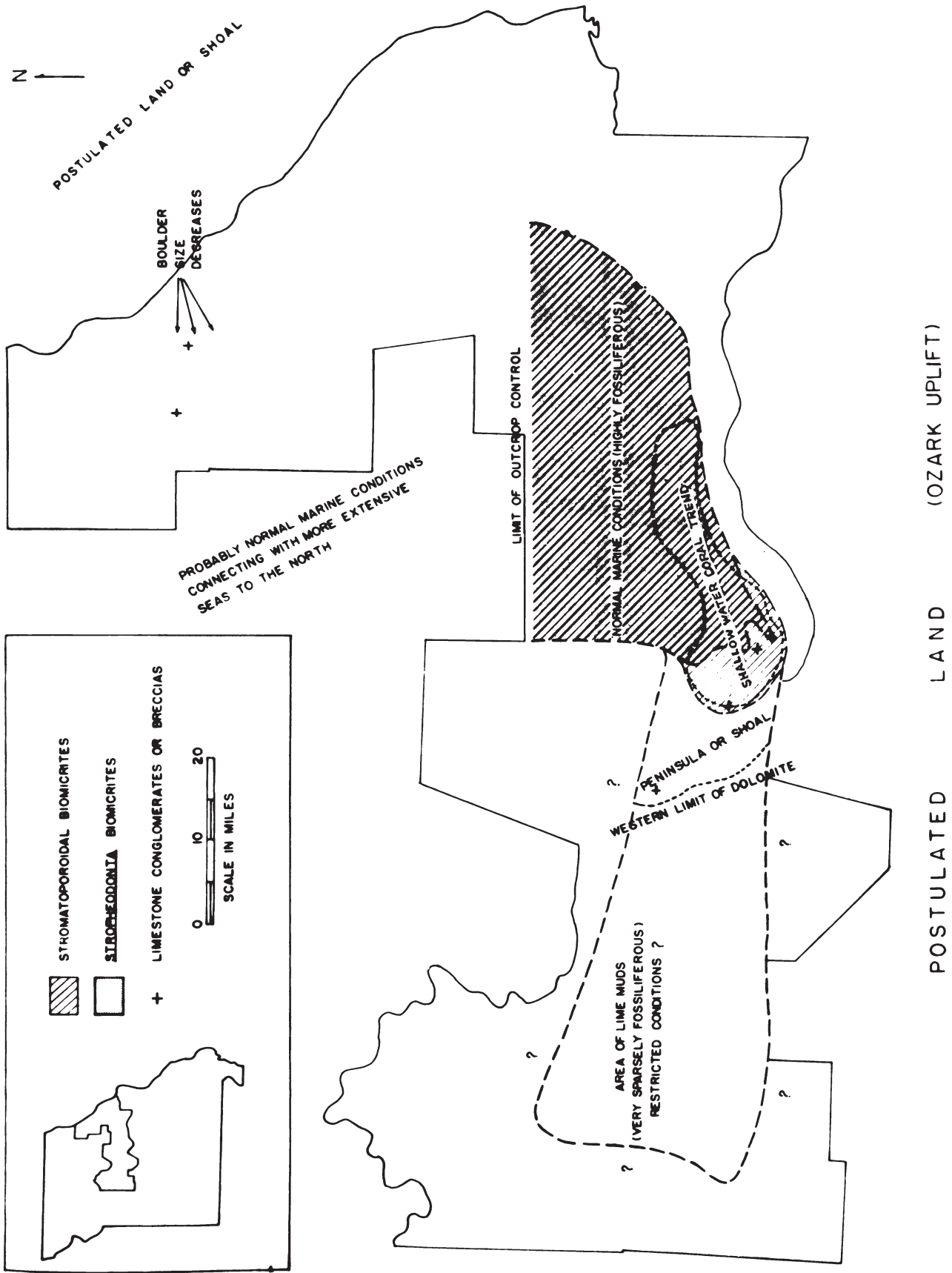


Figure 5. - Paleogeography of the Middle Devonian in central Missouri. (Sleeman, 1964)

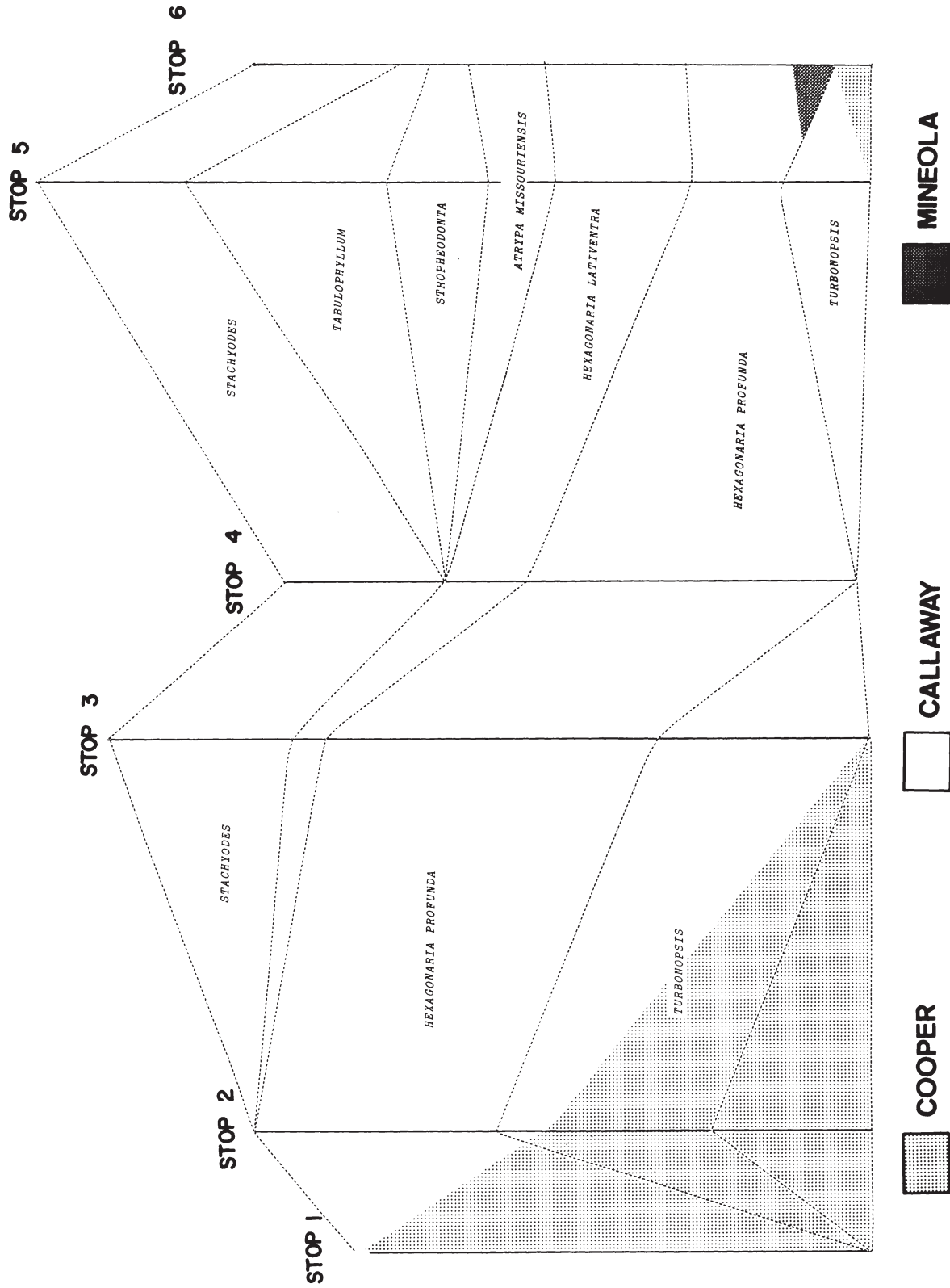
have been included here for the sake of completeness. The Mineola facies is best developed at lower stratigraphic horizons and to the east in Callaway and Montgomery counties.

Two significant rock types, believed to be representative of the Mineola facies, are sandstones (principally orthoquartzites) and biosparites.

The sandstones and biosparites interfinger with no predictable pattern, but they commonly occur in the lower one-third to one-half of a complete Cedar City section (Fig. 3). Locally the biogenic and terrigenous constituents are mixed in various proportions to give hybrid rock types, but more commonly the rock types are either fairly pure sandstone or fairly pure biosparites.

Both the sandstones and biosparites were deposited in near shore, high-energy environments. This conclusion is based on the following criteria:

1. The occurrence of abundant terrigenous sand grains.
2. The interfingering relationship between carbonates (biosparites) and sandstones over short distances.
3. The abundance of abraded and well-rounded fossil fragments.
4. The marked predominance of sparry calcite over microcrystalline calcite.
5. The widespread occurrence of current bedding.



Lithofacies From Sleeman, 1964

Biofacies From Fraunfelder, 1964

BIOSTRATIGRAPHY OF THE MIDDLE DEVONIAN OF CENTRAL MISSOURI

George Fraunfelter
University of Southern Illinois, Carbondale

The Middle Devonian rocks in Central Missouri are referred to here as the Cedar City formation, which includes two limestone lithofacies, the Cooper and the Callaway.¹ The Cooper facies is best developed in west-central Missouri in Saline, Pettis, Morgan, Cooper, and Moniteau Counties. The Callaway facies is best developed in Boone, Callaway, and Montgomery Counties. The Cooper and the Callaway are subdivisible into eight biofacies (Fig. 6); and their Middle Devonian age is documented by the occurrence of *Rensselandia missouriensis* (Swallow). (See measured sections)

Unconformities (marked by erosional breaks and intraformational conglomerates) exist between the Cooper and the Callaway as well as within these two facies. Aside from this, there is a gradational change from fine-grained Cooper limestones, excluding basal terrigenous rocks in west-central Missouri, eastward into conglomeratic limestones of the Callaway facies. The Cooper facies is largely barren of megafossils, except in areas such as northern Moniteau and southern Boone Counties where it interfingers with the Callaway facies.

The back-reef (quiet water) biofacies is characterized by the occurrence of the gastropod *Turbonopsis providensis* (Broadhead) and is associated either with micritic limestones or, near reefs, with fine-grained dolomitic limestones.

The reef biofacies (shoal facies) typically contains *Hexagonaria profunda* and *H. lativentra*. These colonial corals are associated with fine-grained limestones, fragmental limestones, argillaceous limestones, sandstones, dolomites, and dolomitic limestones.

The fore-reef biofacies (basin facies) reflects slightly deeper water. The brachiopod *Atrypa bellula* (Stainbrook) and the associated fore-reef biofacies are largely confined to dolomites. The *Atrypa missouriensis* (Miller) biofacies is usually associated with fore-reef dolomites but occurs in fragmental limestones where it interfingers with the reef biofacies. In back-reef areas it occurs in fine-grained and sandy limestones. The fore-reef *Strophedonta linder* (Stainbrook) biofacies occurs with fine-grained limestones, with

¹Editor's note: Fraunfelter (1964) included the Mineola as a minor facies within the Callaway lithofacies.

argillaceous limestones, and less commonly, with shales. The biofacies containing abundant specimens of the horn coral *Tabulophyllum callawayensis* sp. nov., along with that containing *Stachyodes caespitosa* (lecompte), is restricted to fine-grained limestones. Both are fore-reef in origin.

Three local concentrations of fossils are obvious. The *Thamappora limitaris* (Rominger) beds, which most commonly occupy the base of the *Tabulophyllum* sp. biofacies; the *Rensselandia* beds (*R. missouriensis* (Swallow) and *R. Johanni* (hall)), which occur at the top of the *Hexagonaria profunda* biofacies; and the *Favosites*---*Anostylostroma* beds [*F. alpenensis alpenensis* (Winchell) var. and *A. laxum* Gallaway and St. Jean], which occur in the lower part of the *Hexagonaria profunda* biofacies.

These biofacies correlate with the faunal zones of the Cedar Valley Formation of Iowa (Fig. 7). All of the various lithofacies and biofacies interfinger with one another (Fig. 6).

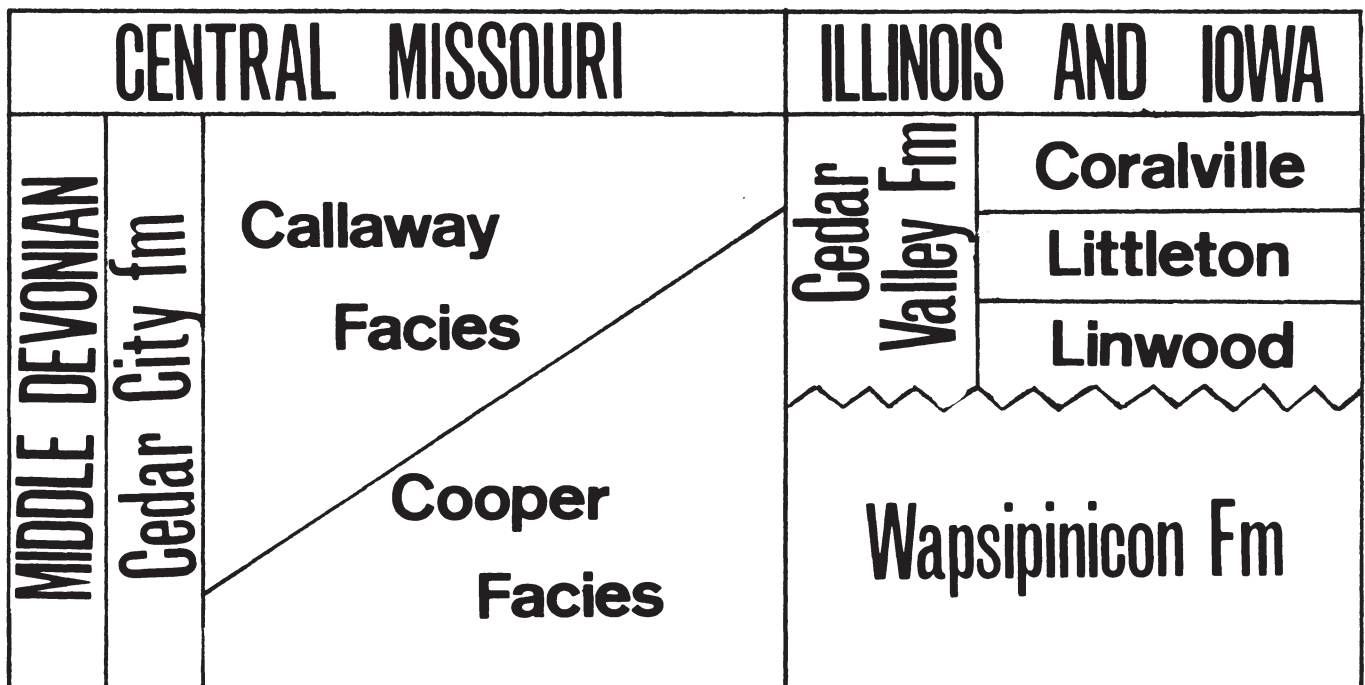
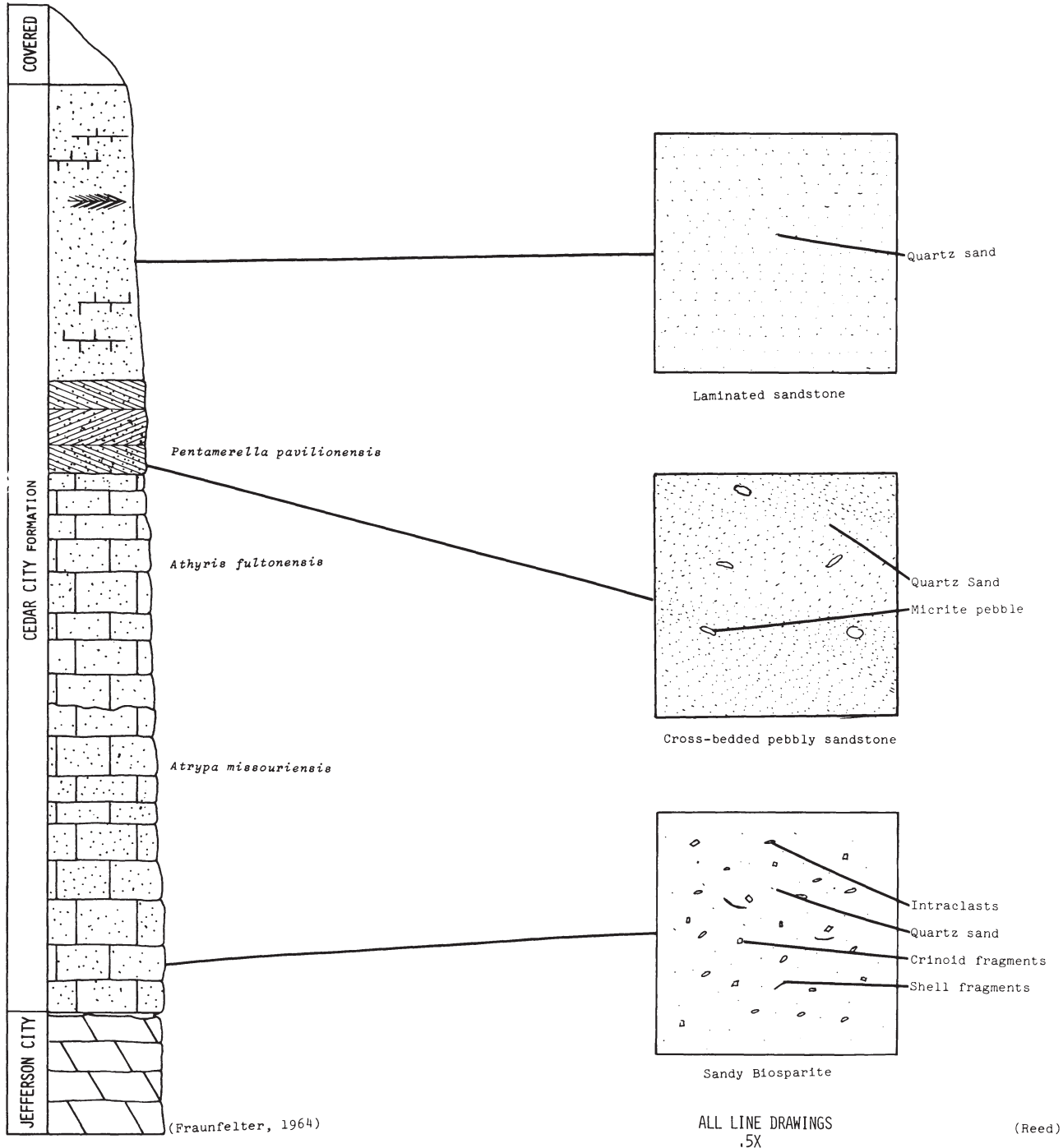


Figure 7. - Correlation of Middle Devonian rocks in central Missouri with those in Illinois and Iowa. (After Fraunfelter, 1964)

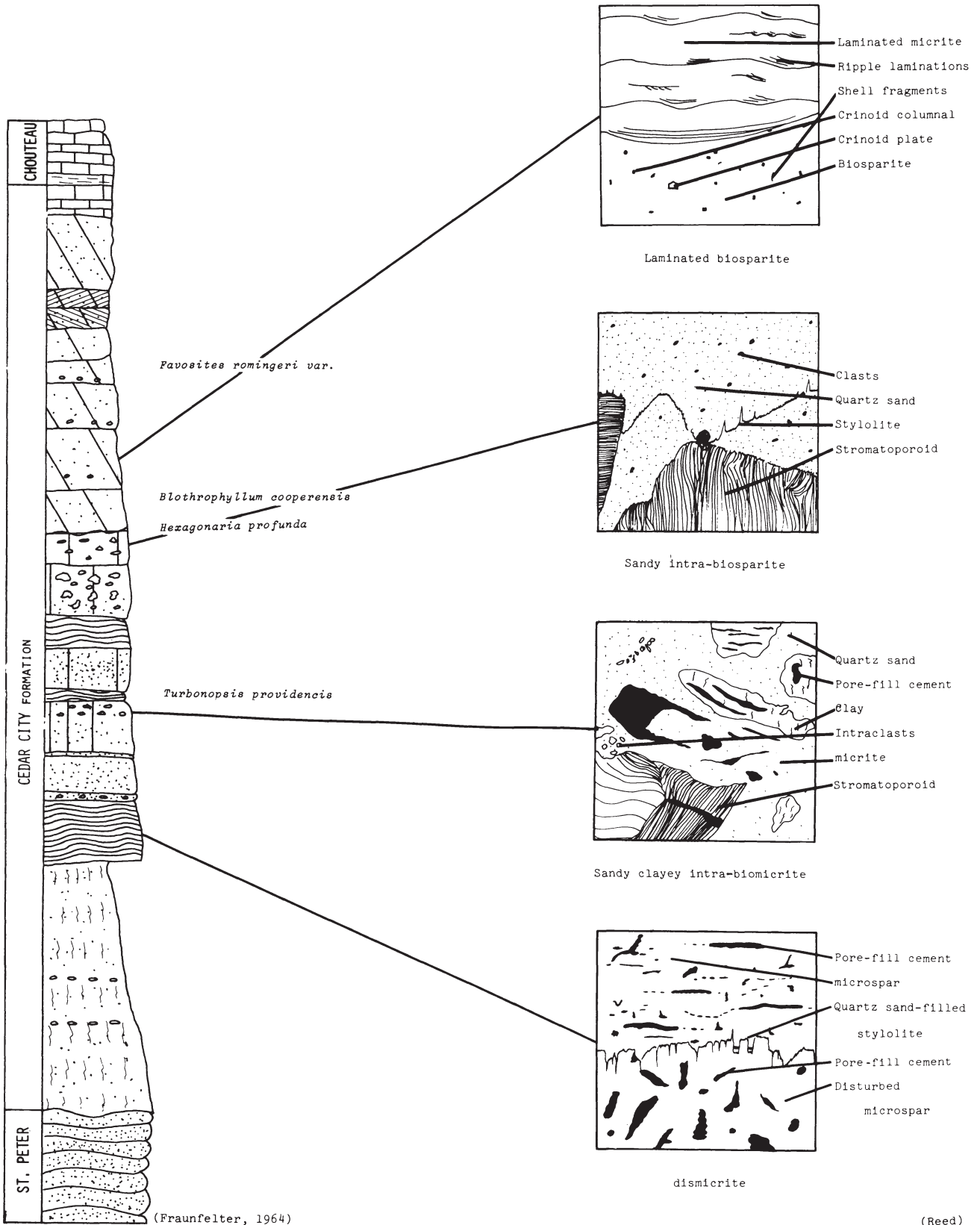
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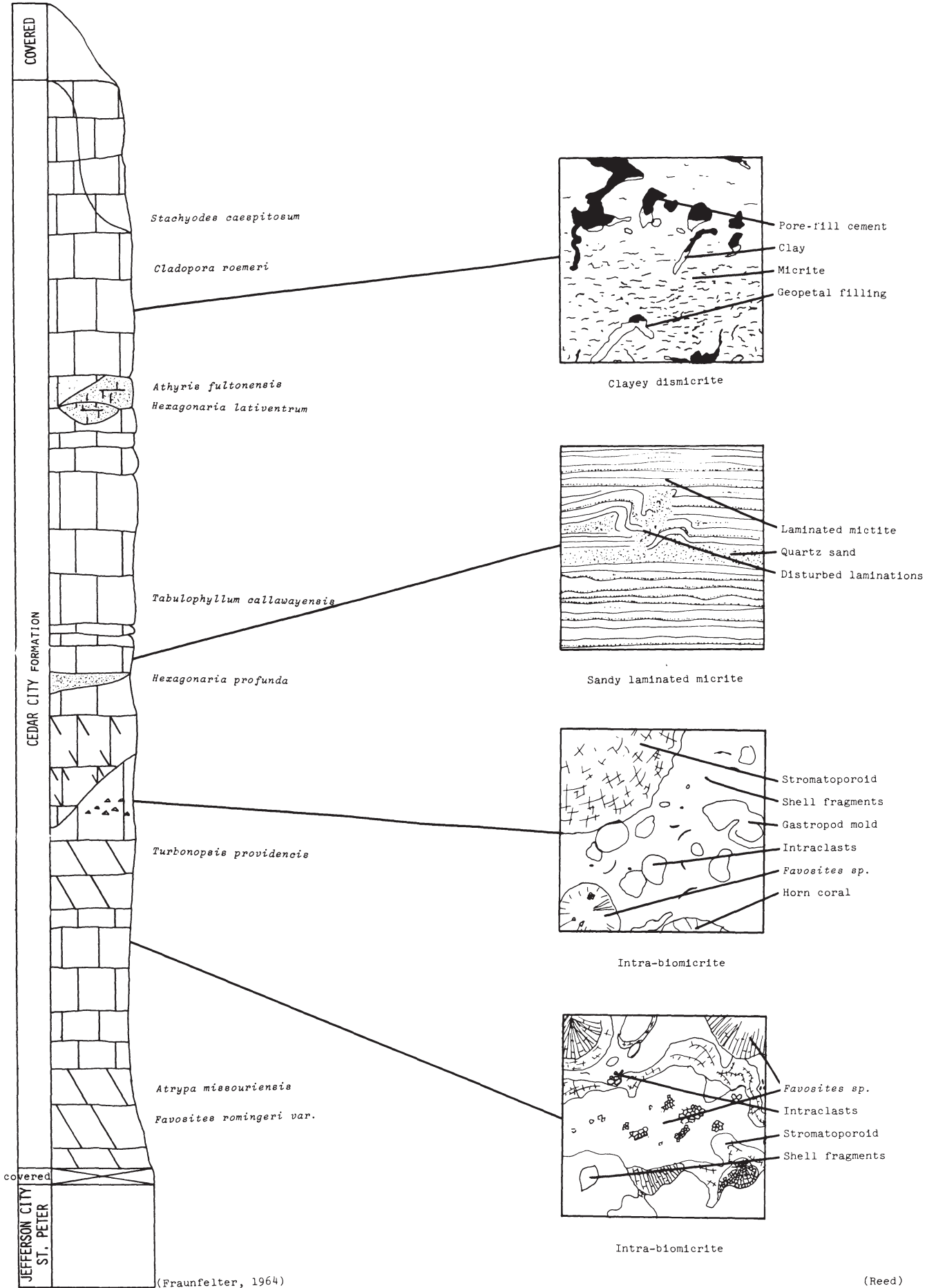
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STOP 2



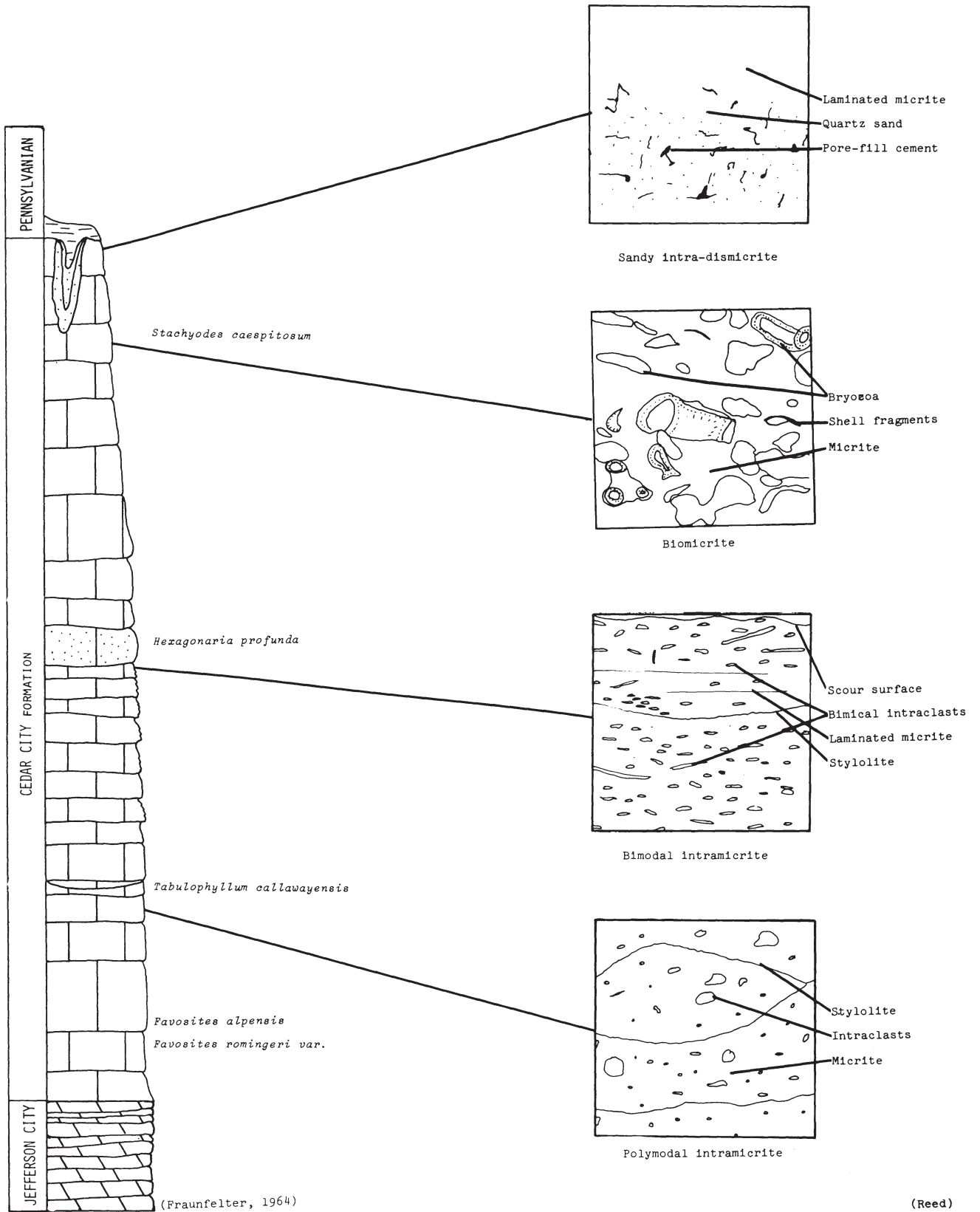
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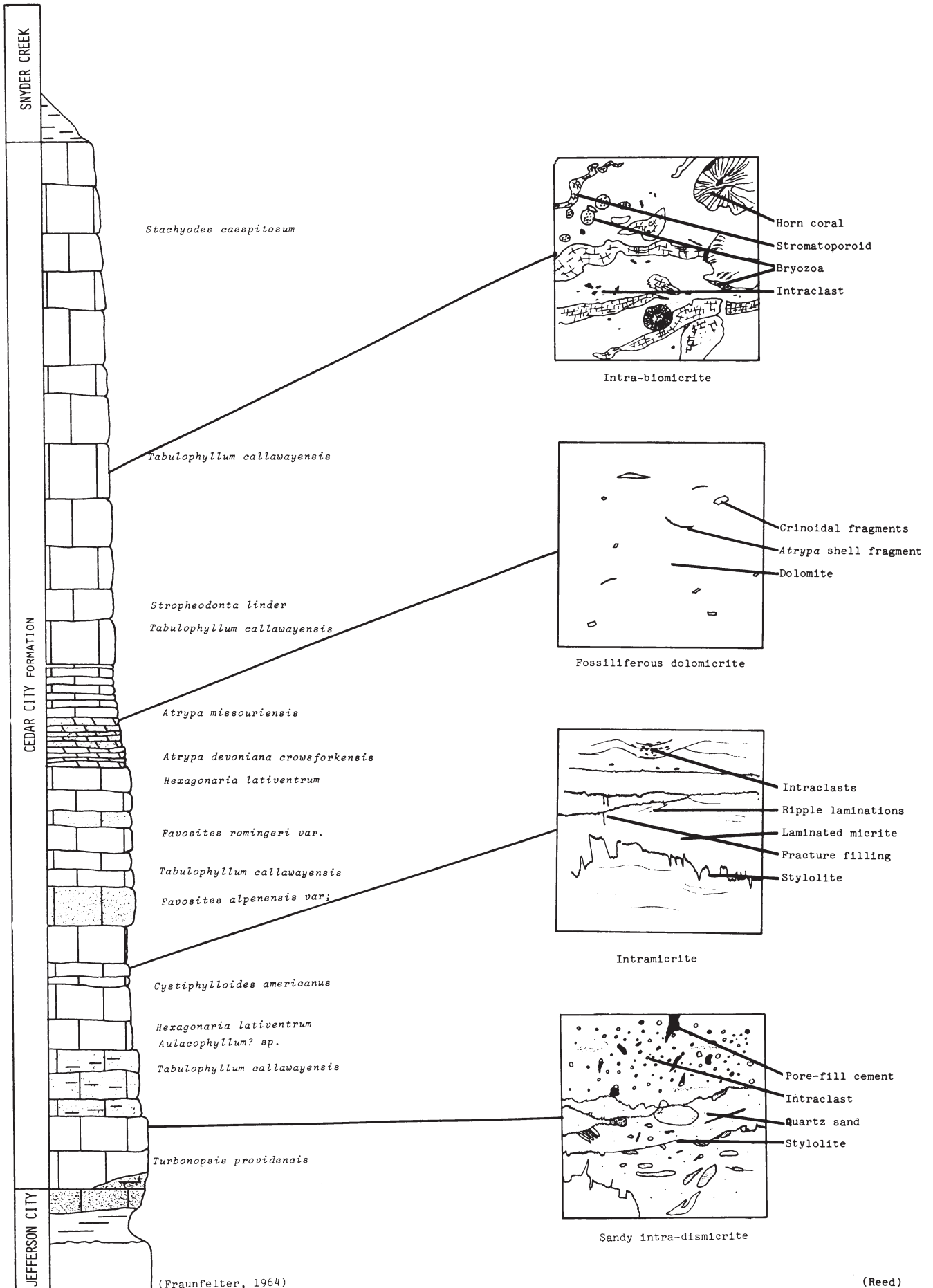
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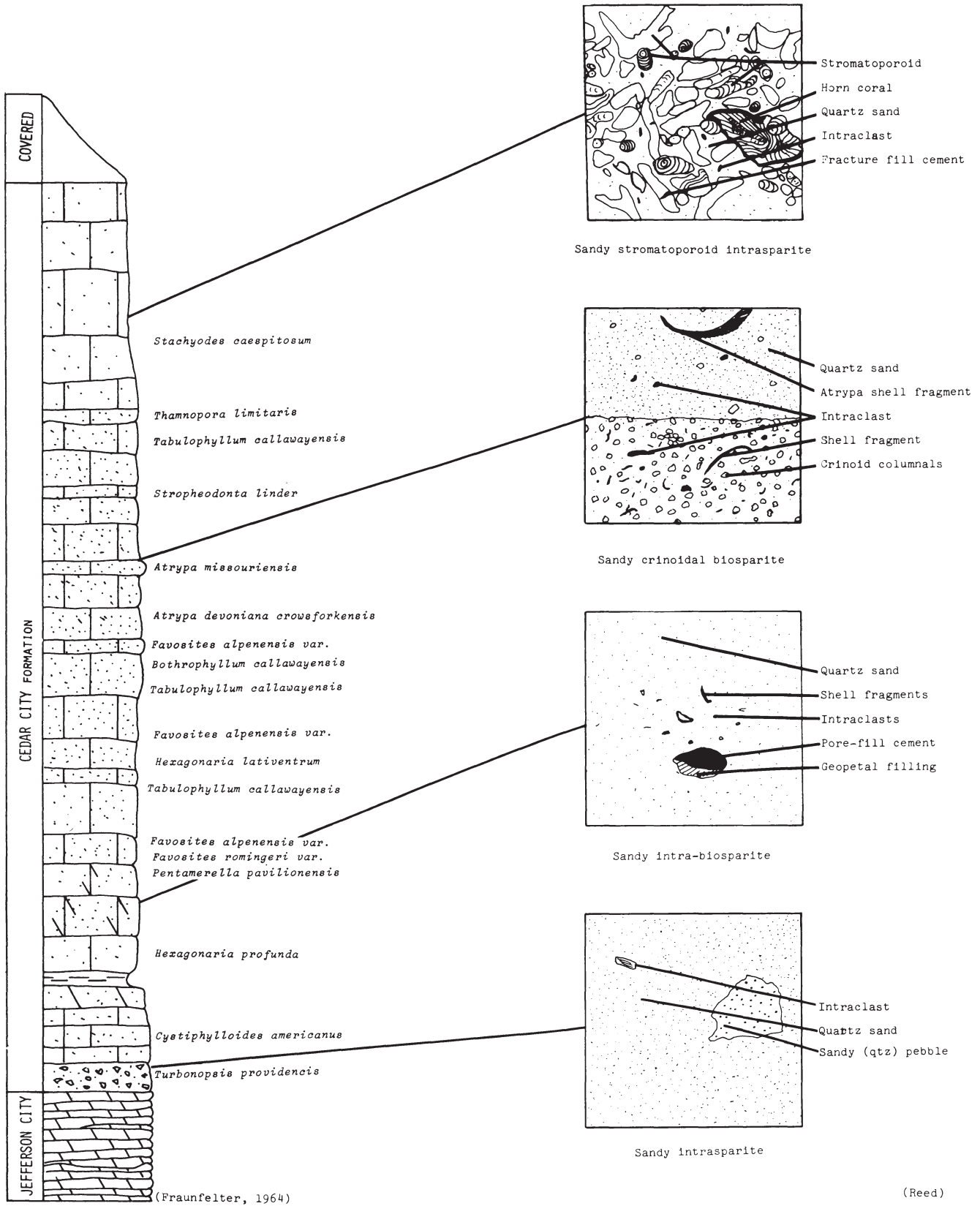


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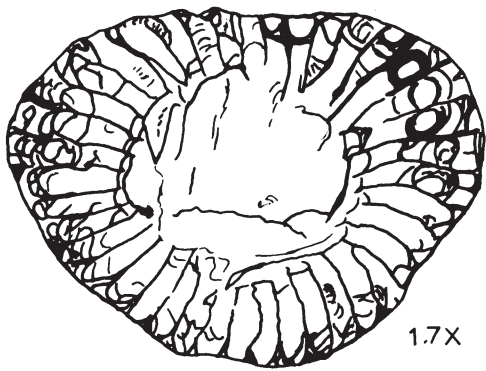


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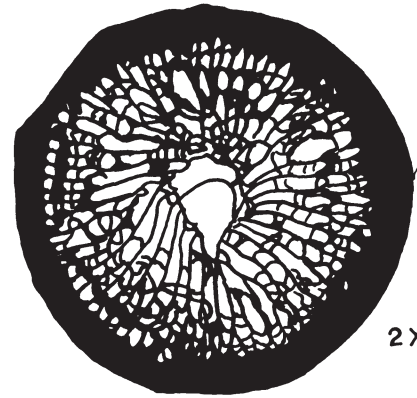


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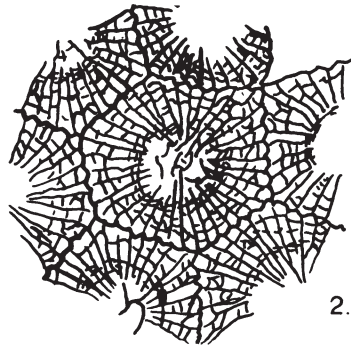
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Tabulophyllum callawayensis



2X

Blothrophyllum cooperensis



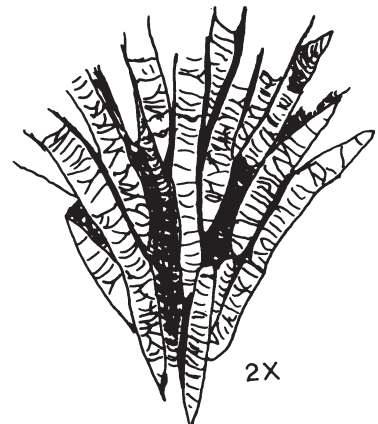
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Hexagonaria Lativentrum



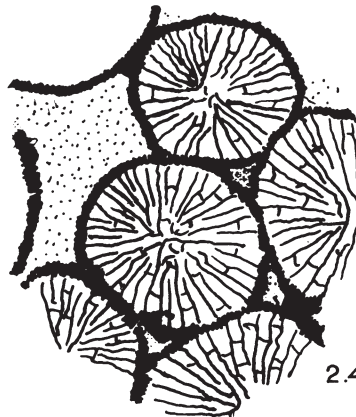
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Favosites alpenensis



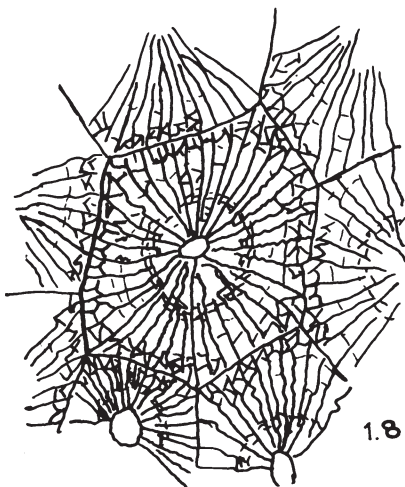
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Favosites rominger



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Hexagonaria profunda



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Eridophyllum callawayensis



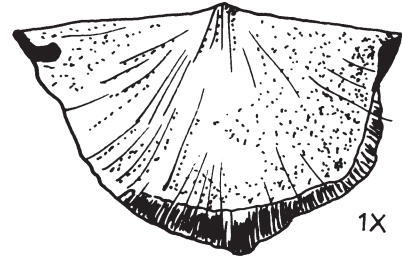
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Stachyodes caespitosa



2X

Cystiphyllodes americanus



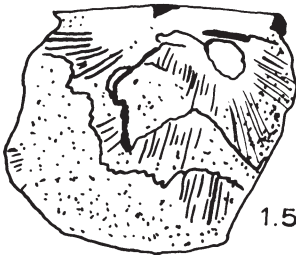
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Stropheodonta littletonensis



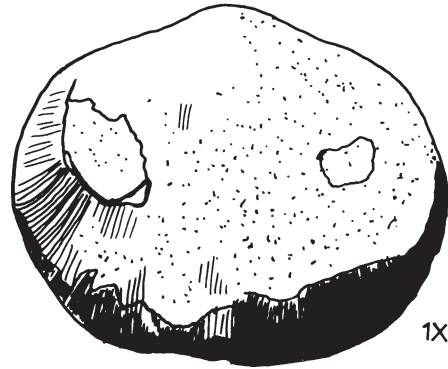
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Athyris fultonensis



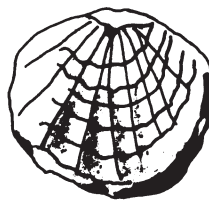
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Schuchertella arctostriata



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Schizopora iowensis



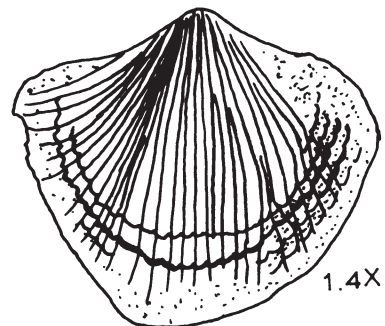
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Atrypa bellula



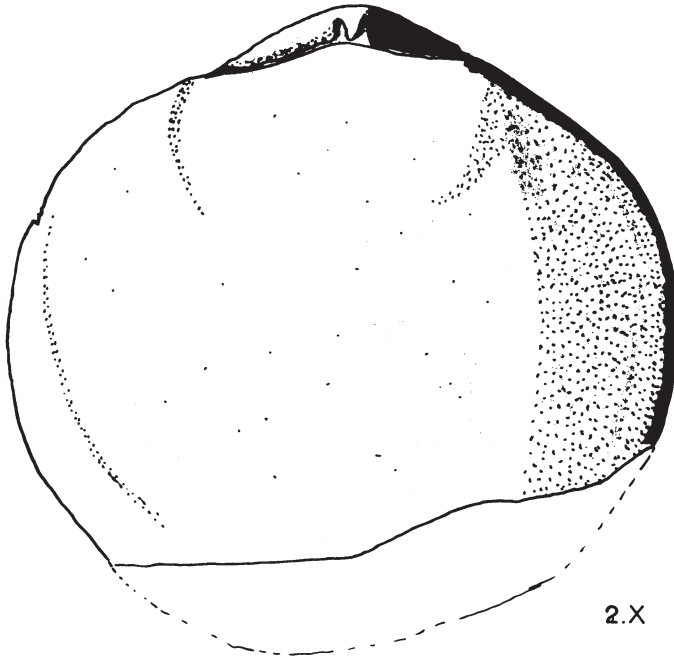
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Stropheodonta linder



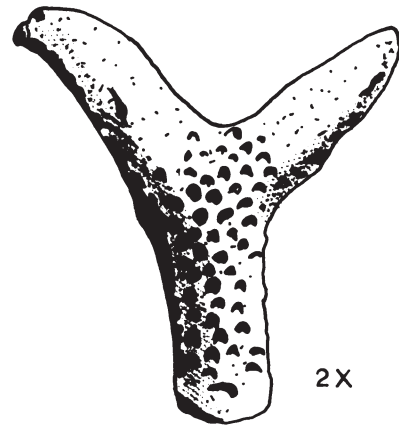
1.4X

Atrypa missouriensis



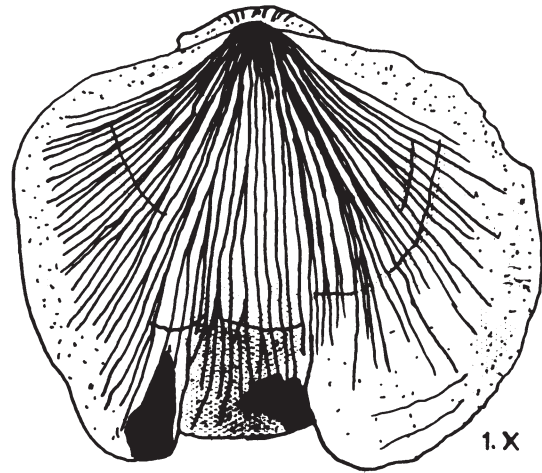
Rensselandia missouriensis

2.X



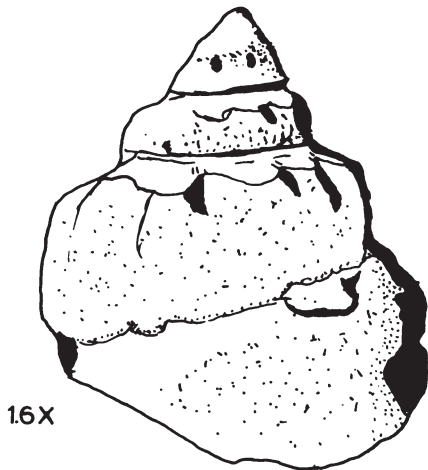
2X

Thamnopora limitaris



1.X

Atrypa devoniana



16X

Turbonopsis sp.

ROAD LOG

Columbia to Lupus

Start: University of Missouri Memorial Stadium, West Parking Lot. Go Westward on Stadium Road (Outer Loop) to Mo. Highway 740 (Conley Lane). Go Northward on Hwy. 740 to I-70; Westward on I-70 to Mo. 179; Southward on Mo. 179 to Moniteau Co. Hwy. P; Eastward on Hwy. P to Lupus.

Mileage:

- 0.0 - Roadcuts along Stadium road are in Burlington (Mississippian) limestone.
- 3.0 - Stoplight--Jct. 740 and TT
- 4.0 - Turn left (west) onto I-70 - Roadcuts in Burlington and Keokuk, intermittently to Mo. 179
- 7.1 - Old U.S. 40 overpass.
- 9.7 - Pennsylvanian shale and limestone in road cut.
- 12.5 - Boone Co. BB overpass
- 13.0 - Loess deposit on Keokuk-Burlington.
- 13.5 - Missouri River. Enter Cooper County.
- 16.4 - Turn left (South) on Mo. 179.
- 18.0 - Jct. Cooper Co. V
- 19.5 - Burlington-Keokuk
- 21.3 - Wooldridge; Turn left; Stay on Mo. 179.
- 24.4 - Enter Moniteau County.
- 24.7 - Jct. Moniteau Co.
- 26.0 - Burlington-Keokuk
- 28.0 - Jct. Moniteau Co. P; turn left (east)
- 32.0 - Lupus. STOPS 1 and 2.

LUPUS TO ADRIAN QUARRY

Go Westward on Moniteau Co. Hwy. P to Mo. 179; Southward on Mo. 179 to Jefferson City and U.S. Highway 63. Follow U.S. 63 northward to Adrian Quarry.

- 32.0 - Lupus.
- 36.0 - Jct. Moniteau Co. P; turn left (south).
- 37.1 - Jct. Mo. 179 and Mo. 87.
- 40.2 - Jct. Mo. 179, Mo. 87, and Moniteau Co. V.
Continue southeastward on Mo. 179.
- 40.7 - Jamestown.
- 45.0 - Sandy Hook; Quarry, partially in Middle Devonian, on left (south) side of road. Rock used mostly for river bank revetment.
- 49.5 - Jct. Mo. 179 and Moniteau County N.
- 50.2 - Marion.
- 52.5 - Jct. Mo. 179 and Cole County Z.
- 55.5 - Jct. Mo. 179 and Cole County T.
- 60.8 - RR crossing
- 62.1 - RR crossing
- 63.4 - Dix road.
- 63.7 - RR crossing
- 64.3 - Right onto High Street
- 64.6 - Left onto U.S. Hwys. 63 and 54.
- 64.8 - Missouri River Bridge.
- 65.3 - Jct. U.S. 63 North and U.S. 54.
- 71.2 - Adrian Quarry. STOP 3

- 00.0 - Leave Adrian Quarry via U.S. 63 South
- 2.0 - MKT RR overpass. Jefferson City formation bluffs.
- 5.9 - Jct. U.S. 63 and U.S. 54. Turn left (north onto U.S. 54)
- 6.9 - Jefferson City Formation bluffs.
- 9.7 - Cedar City type area in HWY 54 roadcuts. STOP 4.
- 11.1 - Holt Summit
- 13.7 - Jct. U.S. 54 and Callaway County AA.
- 14.5 - New Bloomfield
- 19.8 - Jct. U.S. 54 and Callaway County BB.
- 22.0 - Church and Cemetery on left (west) side of road.
- 22.2 - Jct. U.S. 54 and gravel road to right (east).
Follow this road about 1/2 mile to blacktop.
- 25.2 - Turn left (north) and go about 100 yds. Turn right (east)
back onto gravel.
- 28.9 - Jct. gravel road and Callaway County C. Turn right (south)
on C.
- 32.5 - Jct. Callaway County C. and County Callaway AD.
Turn left (east) on AD.
- 33.6 - Turn left (north) on dirt-gravel road.
- 34.8 - STOP 5.
- 35.8 - Jct. dirt-gravel road and Callaway County O.
Turn right (east) on O.
- 36.0 - STOP 6. Buses turn around at bottom of hill and come back
to Stop 6. Proceed to Fulton on Callaway County O.
- 41.0 - Pennsylvanian in road cut.
- 42.0 - Jct. Callaway County O and Callaway County C. Straight
ahead on C. to U.S. 54.
- 42.3 - Jct. Callaway County C and US 54.

NOTE: One can return to Columbia via US 54 northward to Kingdom
City and I-70 westward to Columbia. Or one can return
via Callaway County J westward from Fulton and joining
Boone County WW which extends to Columbia.

Alternate Road Log--Columbia to Adrian Quarry via US 63.
Start at Jct. I-70 and US 63 South.

- 00.0 - Pennsylvanian outcrops just west of junction and along right
(west) side of US 63.
- 00.7 - Columbia Brick Plant and clay pits on right (west).
Not easily seen.
- 1.3 - Jct. US 63 and Boone County WW.
- 2.3 - Burlington-Keokuk-Pennsylvanian in roadcuts.
- 3.6 - Jct. US 63 and Old US 63.
- 7.7 - Deer Park
- 13.6 - Ashland.
- 19.5 - Jefferson City Formation in road cuts.
- 20.8 - Cedar City--Bachelor--Chouteau in road cuts.
- 21.0 - Jefferson City--Cedar City--Chouteau--Burlington in roadcuts.
- 21.5 - Adrian Quarry on left (east) side of road.

Folk's Classification

Allochem ("Grains") occur either "floating"
In microcrystalline matrix ("micrite"), or packed
Together and cemented with calcite ("spar").

Analogies:

Sandstones

Quartz.....Grains

ClayMicrite

CementCement

Limestones

Prefix of Rock Name denotes kind of grain:

biofossil

intraintraclasts (soft sediment "Pebbles")

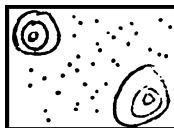
pel.....pellets (faecal in origin)

oö.....oölites

Suffix denotes interstitial material (i.e., micrite or spar)



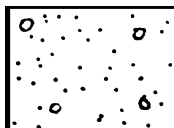
biomicrite



oömicrite



intramicrite



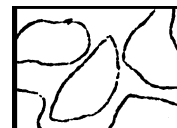
pelmicrite



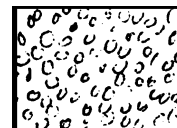
biosparite



oösparite



intrasparite



pelsparite