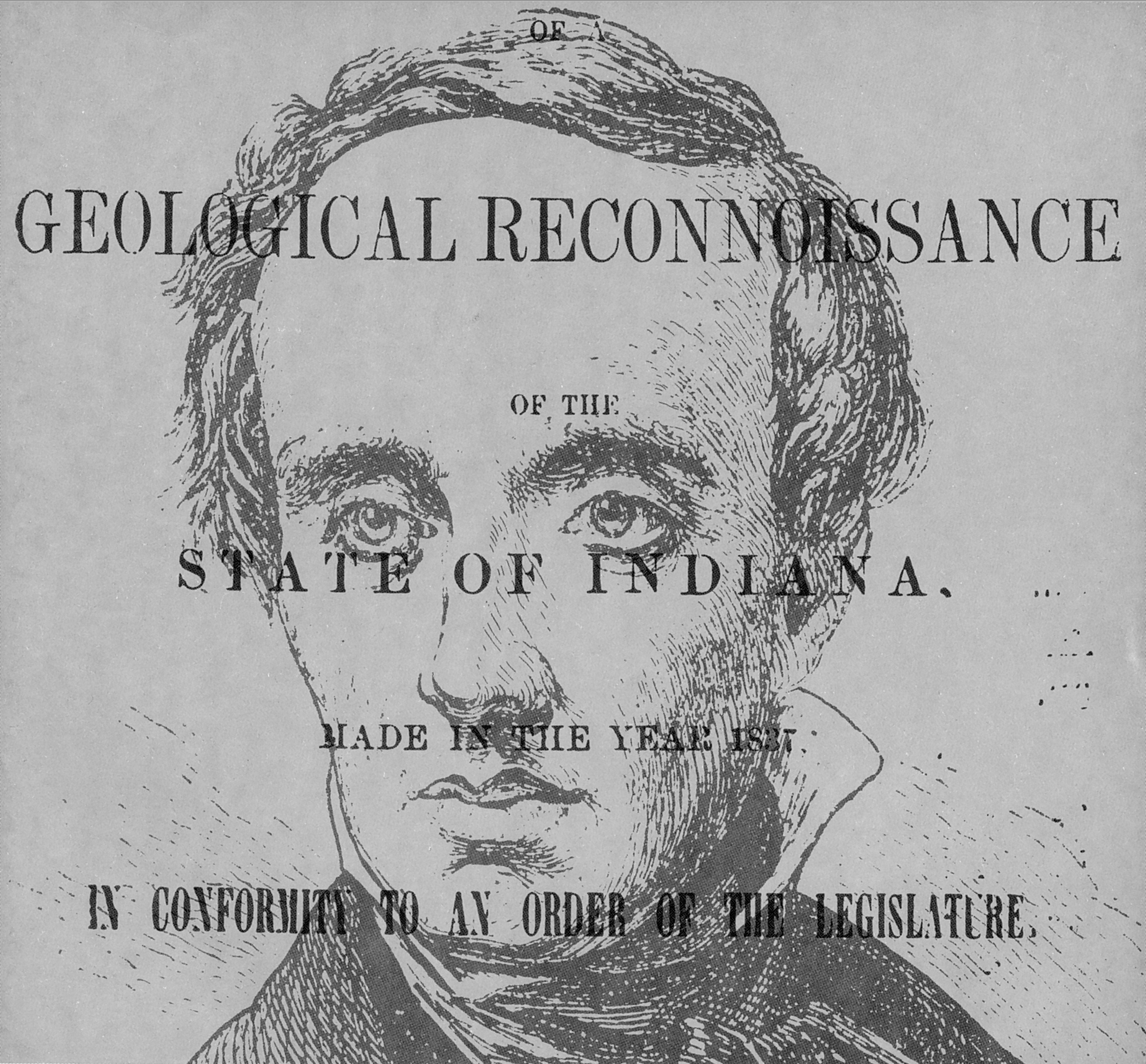
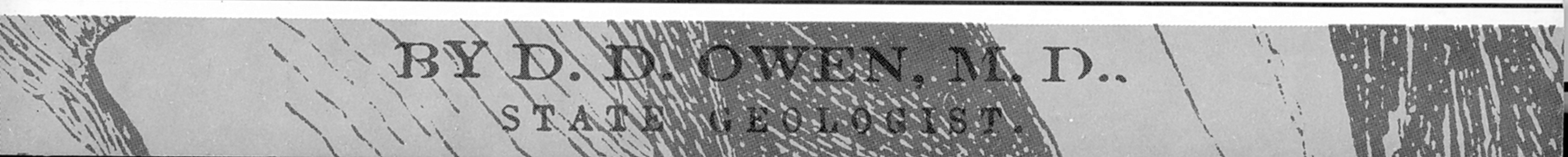


Stratigraphy of the Silurian Rocks of Northern Indiana

Compiled by Robert H. Shaver



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Field Conference Guidebook No. 10

STRATIGRAPHY OF THE SILURIAN ROCKS OF NORTHERN INDIANA

by

Robert H. Shaver

With contributions by

Henry H. Gray, Arthur P. Pinsak, Jack A. Sunderman,
William D. Thornbury, and William J. Wayne

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PROGRAM

Friday, May 5, 1961

3:30 to 10:30 p.m. :	Registration and distribution of guidebooks; purchase tickets for box lunches for Saturday and Sunday and for dinner, Saturday evening. Lobby, Spencer Hotel, Marion.
8:30 to 10:30 p.m. :	Formal papers and discussion. Ballroom.

Saturday, May 6

7:45 a. m. to 5:30 p.m.: Five field stops; bus transportation.

7:00 to 8:30 p. m. :	Dinner, Colonial Room.
8:30 to 10:30 p. m. :	Formal papers and discussion. Ballroom.

Sunday, May 7

7:45 a. m. to 12:00 noon: Three field stops; private auto transportation.

All times are Central Daylight Time.

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STRATIGRAPHY OF THE SILURIAN ROCKS OF NORTHERN INDIANA

By Robert H. Shaver

ABSTRACT

The Tenth Indiana Geologic Field Conference treats of the basic stratigraphy of the Silurian rocks that lie between the Cincinnatian rocks and the bedrock surface in the rectangular area whose corners are defined by Cass, Allen, Randolph, and Hancock Counties, Ind. The area forms part of the Tipton Till Plain and is mantled by Wisconsin tills of the Tazewell and Cary Substages. Thus, well logs and cores are essential to an interpretation of the bedrock stratigraphy, but the eight exposures in the itinerary nearly span the Niagaran and Cayugan? Series as known in Indiana.

Lowermost Silurian rocks, not exposed in the area, are assigned to the Brassfield Limestone. Three principal post-Brassfield pre-Mississinewa stratigraphic units are here called “lower Niagaran rocks” and are thought to be correlatives of the Osgood Formation and Laurel Limestone, the Waldron Shale, and the Louisville Limestone of southern Indiana. These rocks are present at the bedrock surface in the southeastern and eastern parts of the conference area. Progressively younger rocks are found westward and northward and are assigned to the Mississinewa Shale, the Liston Creek Limestone, the Huntington Dolomite, and the Kokomo Limestone.

The Huntington Dolomite of common usage consists of lower Niagaran rocks, generally bedded, in the eastern and southeastern parts of the area and of upper Niagaran rocks, commonly reef facies, in the northern part. The so-called New Corydon Limestone of Huntington County is in the upper part of the Niagaran, but the New Corydon type exposures in Jay County lie stratigraphically well below the Mississinewa Shale.

The Kokomo Limestone in its type area is assigned to the Cayugan, but its age and the unconformity that has been described at its base remain questionable. The rocks near Fort Wayne that have been called “Kokomo” are thought to be early-middle Devonian in age. They rest upon rocks of an upper Niagaran reef facies in the one exposure. Southeastward along the Silurian-Devonian contact in the western part of the area Devonian rocks rest upon progressively older Silurian strata, and most of the Mississinewa and younger Niagaran rocks are absent from the southern part.

The historical development of stratigraphic terminology and the latest stratigraphic data suggest that the present usages of names for the following rock units in the conference area are less than satisfactory and that revision and redefinition may follow definitive study: Brassfield Limestone, lower Niagaran rocks, Huntington Dolomite, and New Corydon Limestone.

Much of the fossil evidence bearing upon early correlations consists unsatisfactorily of species lists that had grown from author to author and through stratigraphic revisions. Many species, from nontypical exposures but presumably characterizing the faunal type, were added after stratigraphic identification had been made by means of lithostratigraphy; nearly half of the classic fossil localities are here assigned new stratigraphic positions. The fauna from the Mississinewa Shale and younger Niagaran strata is thought to be Lockport and Guelph in age.

INTRODUCTION

One hundred and twenty-two years ago in London, Roderick Impey Murchison (1839) wrote:

> Having discovered that the Region formerly inhabited by the Silures, celebrated in our annals for the defense of the great Caractacus, contained a vast and regular succession of undescribed deposits of a remote age, I have named them the “Silurian System.”

In the same year and 4,000 miles southwestward, David Dale Owen (1839) observed that:

> The first appearance of a ledge of rock, on the west fork of the White River is at McIntyre's in Randolph County. It lies low, and is difficult of access. A little below Muncietown in Delaware County, it is better exposed, and building rock can be procured, though only in thin layers.

At the same time, Owen proposed in Indiana to

> make a rigorous comparison between (the fossils) and those found in other parts of America and Europe, with a view of discovering the correspondence between our formations and those of other parts of the United States and the Eastern hemisphere.

Only a few decades earlier had the great discovery of faunal succession been stated, and Owen interpreted it thusly:

the relative ages, and consequently nature and position, of the various members of the stratified formations, is best ascertained, not from the lithological character, but from the occurrence and non-occurrence of the petrified remains of animals and plants.--This order of succession, in every known portion of our globe, is invariable.-Thus, the first group, if found at all, lies universally above all the others; the second, above all except the first; and so on to the end.

And so even at the time of first mention of rocks now called “Silurian” at Muncietown, stratigraphers had embarked upon two of their great tasks, those of describing sections of rocks and of correlating them with other sections. One hundred and twenty-two years later we find ourselves at the Tenth Indiana Geologic Field Conference with much the same purposes but restricted in scope on this occasion to the Silurian rocks in northern Indiana. Our difficulties remain as great today as those confronting Owen when he proposed his paleontologic scheme for the correlation of Indiana's rock formations. We cannot yet assign with certainty all the Indiana middle Paleozoic rocks to either the Silurian System or the Devonian System. Has our heritage and its grand purpose failed us then?

Not at all, for while some correlations in old reports have not stood the test of time, others have, and both groups provide the framework from which we can, with our cumulative knowledge, reap the greater benefit at this time. Thus, David Owen began the framework which we now take for granted; he was immediately successful in properly “Silurian” to the rocks at Muncietown, Andersontown, and, indeed, to much of the bedrock of the upper Wabash country.

The principle of layer-cake stratigraphic paleontology served the succeeding generations well. By the time of Richard Owen' s (1862) report, Silurian rocks in northern Indiana had been identified on a finer scale and were assigned mostly to the Niagara Group of Hall (1842). To the south, the lower of Hall's series, now called “Albion” (Kindle and Taylor, 1913) and as represented by the fauna of the Brassfield Limestone, had been recognized. Both of these determinations stand accepted today. Unfortunately, another determination appears to have gone unheeded until now, for A. J. Phinney, M. D. (1883, p. 187), recognized the proper order of stratigraphic succession of four then unnamed rock units from Randolph County northwestward to the Wabash River.

The special geologic phenomena that are peculiar to the Silurian strata of northern Indiana spurred the study of these rocks and their subdivision into yet smaller units. We have only to mention eurypterids to gain an insight to the inspiration that led to several classic reports on the fossils. The word “reef” seems to have magnetic appeal for geologists, but no less appeal did the Niagaran reefs have when designated earlier as “upheavals,” “erosion cones,” “mud lumps,” “islands of rock,” and “ quaquaversal structures.” In the economic field, “lime burning,” “quarry stone,” “ Waterlime,” “the Gas Area,” “Wabash flaggings,” “shell rock,” and rock wool were stimulating influences. By 1925 approximately 60 authors had contributed information bearing directly on the Silurian stratigraphy of northern Indiana. They also had applied more than 20 formal names of varying ranks to subdivisions of these strata, nearly all of which *were* defined or correlated under the banner of stratigraphic paleontology.

But how well would the shining principle, “order of succession is invariable,” stand the test of ever finer subdivision? Most authors of the time probably were unaware that the scale of evolution, as it could be interpreted from their paleontologic methods, had not kept pace with the scale of rock subdivision that had been attained; probably, most were unaware that at that scale ecology had overmatched evolution in impressing its stamp upon the faunas. That there was an awareness in some quarters is shown by references to now-classic” recurrent Lockport and Guelph faunas” and by such statements as: “They (Guelph forms) may have first appeared in the more favorable environment of the reefs” (Cumings and Shrock, 1928b, p. 82).

The work that was undertaken by Cumings and Shrock during the period 1921 through 1930 and culminated in their monograph, “The Geology of the Silurian Rocks of Northern Indiana" (1928b), was, and remains today, the most comprehensive work on the Silurian rocks of the field conference area. Yet much information concerning the Silurian rocks of northern Indiana has been gathered during recent years by members of the Indiana Geological Survey and the Department of Geology at Indiana University and by other persons. Particularly, we have many new cores and cuttings from wells, and thicker sections are exposed in old and new quarries. The newer data throw additional light on the Silurian stratigraphy of northern Indiana and permit new interpretations, some of which could not have been made prior to this Tenth Indiana Geologic Field Conference.

Our interpretations must be tempered by the particular background we have inherited. Thus, the framework of stratigraphic nomenclature into which we try to fit the rocks is still that of Cumings and Shrock. Their work probably should be considered as a remarkable advance over that of their predecessors in that it had appreciable consideration for the control by reefs of both lithologic and biologic facies; yet we should remember that it was the first of its kind on our Silurian rocks and that our subsurface data reveal a far larger number, possibly, of the domed reef structures than earlier authors suspected. And what of our large areas of porous, fossil-fragmental, and massive or bedded dolomitic rocks that do not display the locally steep dips? Are these rocks not as well considered broad reef-detrital facies of one or more formations than as a unit in a nicely layered sequence? We should remember also that the inherited stratigraphic framework stands partly on paleontologic supports at the formational level but that standard practices of today hold that the basic stratigraphic unit, the formation, should not be biostratigraphically dependent.

We intend during this conference, then, to consider redefinitions and new correlations of formations as they are traced away from their type sections, to consider introducing new names and borrowing appropriate names from surrounding regions, and to reevaluate the role of our Silurian fossils; yet, our purpose must not be to sweep away tradition but to make the most of it.

THE ROCK UNITS

A core from the site of the abandoned Markland Avenue Quarry in Kokomo, Howard County, extends 407 feet from the youngest known Silurian rocks in the field conference area into 15 feet of Cincinnatian shale and limestone. This core is on display at conference headquarters and will serve (log on page 13 and fig. 1) as a graduated anchor post from which our observations will diverge laterally and upward until we have considered all the Silurian rocks as parts of conveniently layered and superimposed units in the stratigraphic tradition. We must keep up to date in that tradition, however, and expect that layers more likely are irregularly digitated and mounded and that interpenetration occurs wholesale both laterally and vertically.

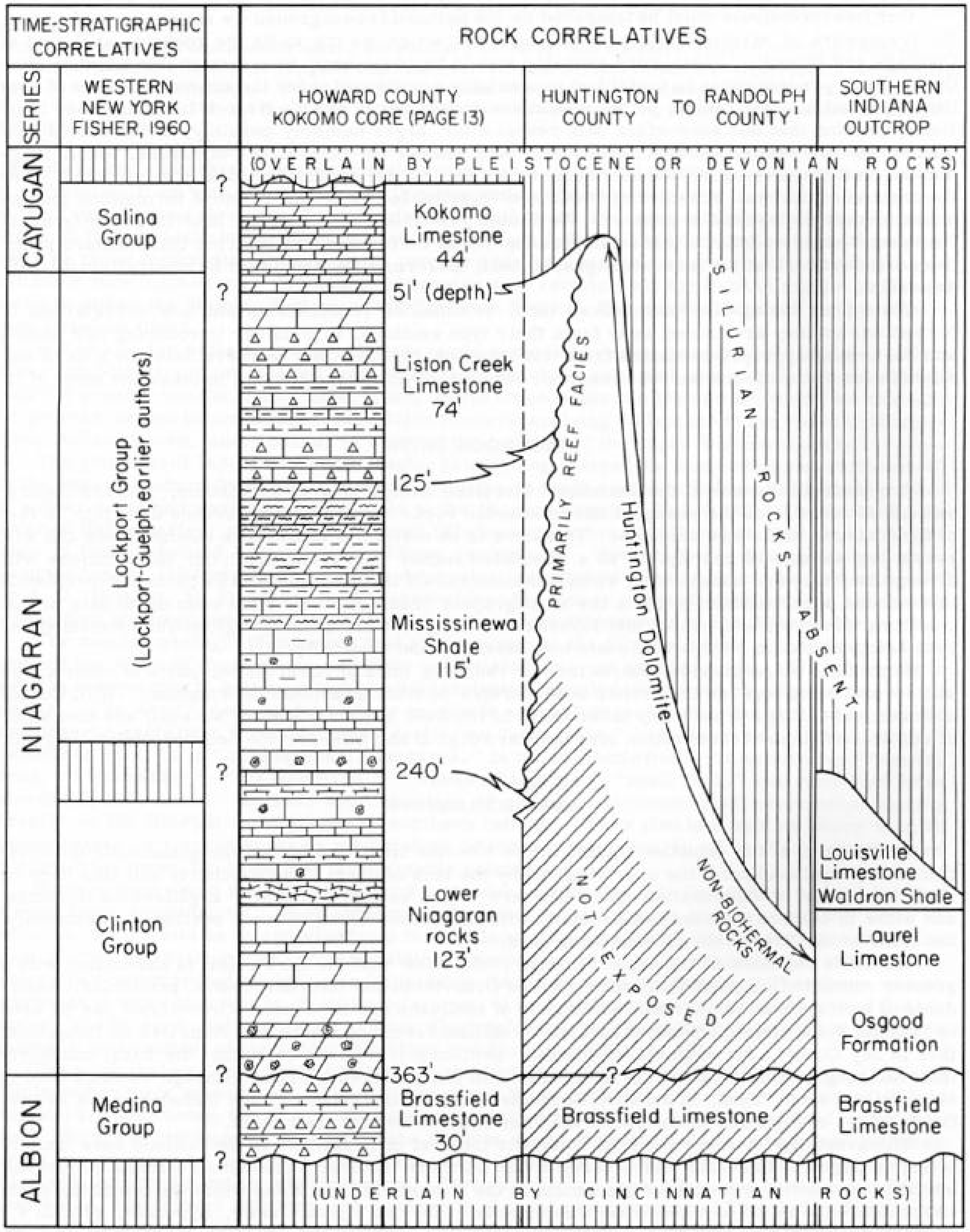
Eight field stops provide control for our radiating lines of observation; parts of other cores and several strip logs at conference headquarters provide additional information. With the aid of cores and cuttings from many other wells in the field conference area, we shall see how some of our present lines of observation rise eastward (fig. 2) and intersect the bedrock surface (fig. 3).

BRASSFIELD LIMESTONE

At the base of the Silurian section in the Kokomo core is 6 feet of tan glauconitic dolomite that is distinguished from the overlying unit by the lack of chert. The noncherty unit lies here on shaly limestone of Cincinnatian age; elsewhere it lies variably on shale, argillaceous dolomite, and white to colored granular limestones, without obvious break in some sections. Commonly, the color of the Brassfield darkens downward.

Insoluble residues of the basal Silurian rocks show that the dark color is associated with a greater content of clay and iron oxide. Mixed Ordovician and Silurian fossils, particularly conodonts of both ages at one horizon, and molds of mollusks and bryozoans (Ordovician) can be used to indicate the systemic contact accurately in difficult sections where limestone lies on limestone. (See in Jay County, for example, Appendix, section 3.). Cores show that the basal noncherty interval ranges from 2 to 25 feet in thickness in the conference area, although cuttings tend to obscure this fact. Thus, in subsurface studies these rocks generally are included in the Brassfield, whose recognition in the subsurface has come to depend upon chert.

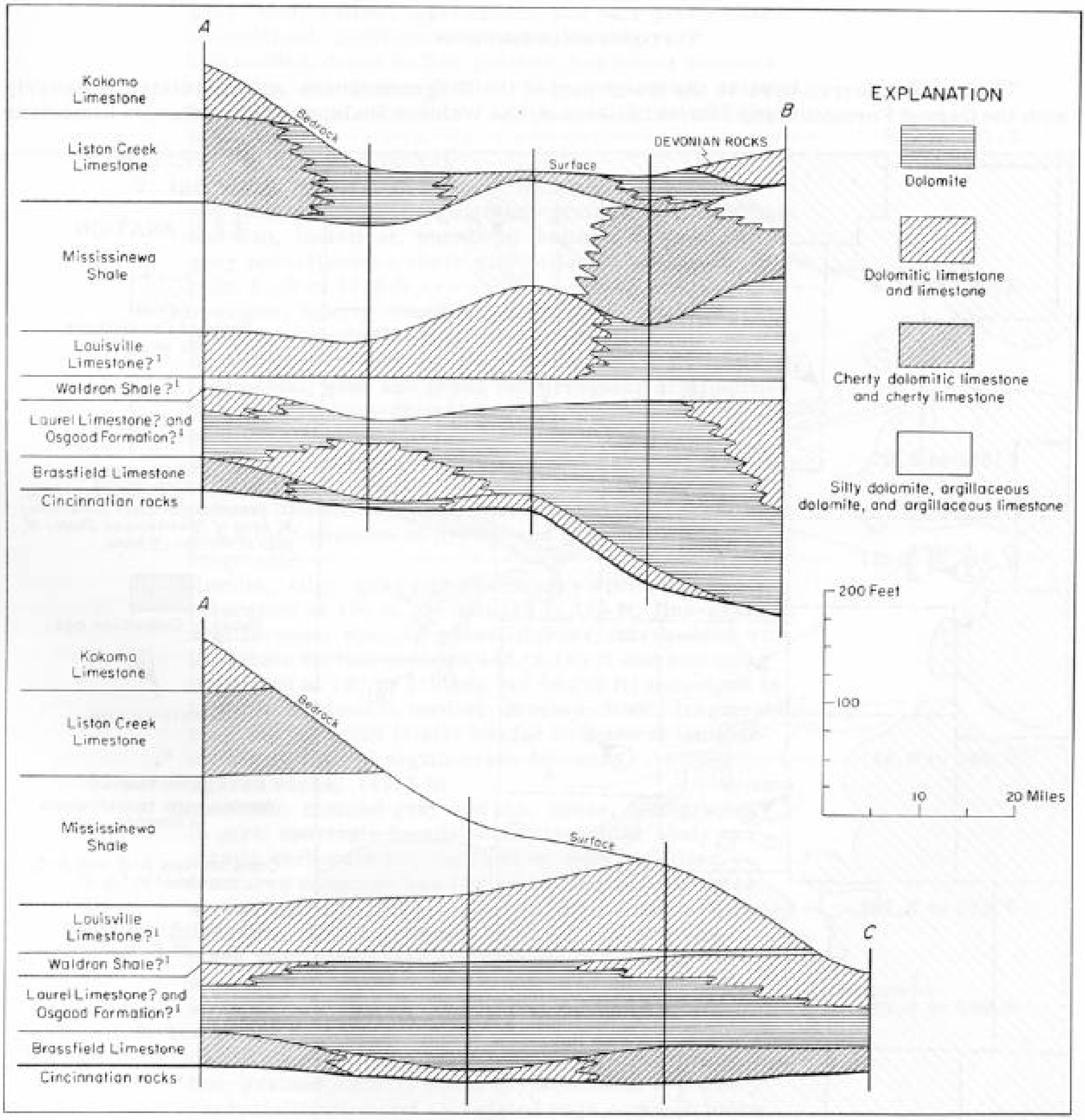
The overlying 24-foot tan cherty dolomitic interval of Brassfield in the Kokomo core (unit 10 of log on page 13) is rather characteristic for northern Indiana. Insoluble residues almost invariably reveal the presence of glauconite in the Brassfield. In some wells the top of the chert is found as high as 50 feet above the Cincinnatian. (See in Tipton County, Appendix, section 4.) This cherty zone, based on cuttings, is 90 feet thick in Tippecanoe County (Rago, 1952, pl. 2), but there is no chert at the expected Brassfield position in Grant County (Appendix, section 2); in that area Esarey and Bieberman (1948, p. 25) suggested erosion or nondeposition of the Brassfield.



[1]Column shows stratigraphic range of rocks that have been called Huntington Dolomite.

Figure 1. --Correlation of the Silurian rocks of the conference area.

The upper contact of the Brassfield in the Kokomo core is additionally distinct, inasmuch as intercalated shale and brecciation are evident at the top of the formation. These characteristics support the argument of many authors that there is an unconformity at the top of the Brassfield, but many cores do not show a distinct break downward except for the appearance of chert. (See the Jay County core.) Furthermore, the chert commonly is unaltered and lacks the earthy luster seen in the Kokomo core.



[1]Included in unnamed beds of Esarey and Bieberman (1948).

Figure 2. --Stratigraphic diagrams showing correlation of Silurian rock units in the conference area. For locations of sections see figure 3.

The Brassfield exposures nearest the field conference area are near Richmond where lithology of the Brassfield, commonly lacking chert, is considerably different from that of the subsurface. North of the field conference area in the Michigan Basin the Brassfield equivalents are included in the Cataract Formation. The last outposts to which we refer our Michigan readers are two wells in Fort Wayne where the cherty Brassfield Limestone probably lies at a depth of 555 to 630 feet. (See Cumings, 1930a, p. 187, who labeled this interval Liston Creek.)

LOWER NIACARAN ROCKS

The rocks referred here to the lower part of the Niagaran Series are correlated tentatively with the Osgood Formation and Laurel Limestone, the Waldron Shale, and the Louisville Limestone

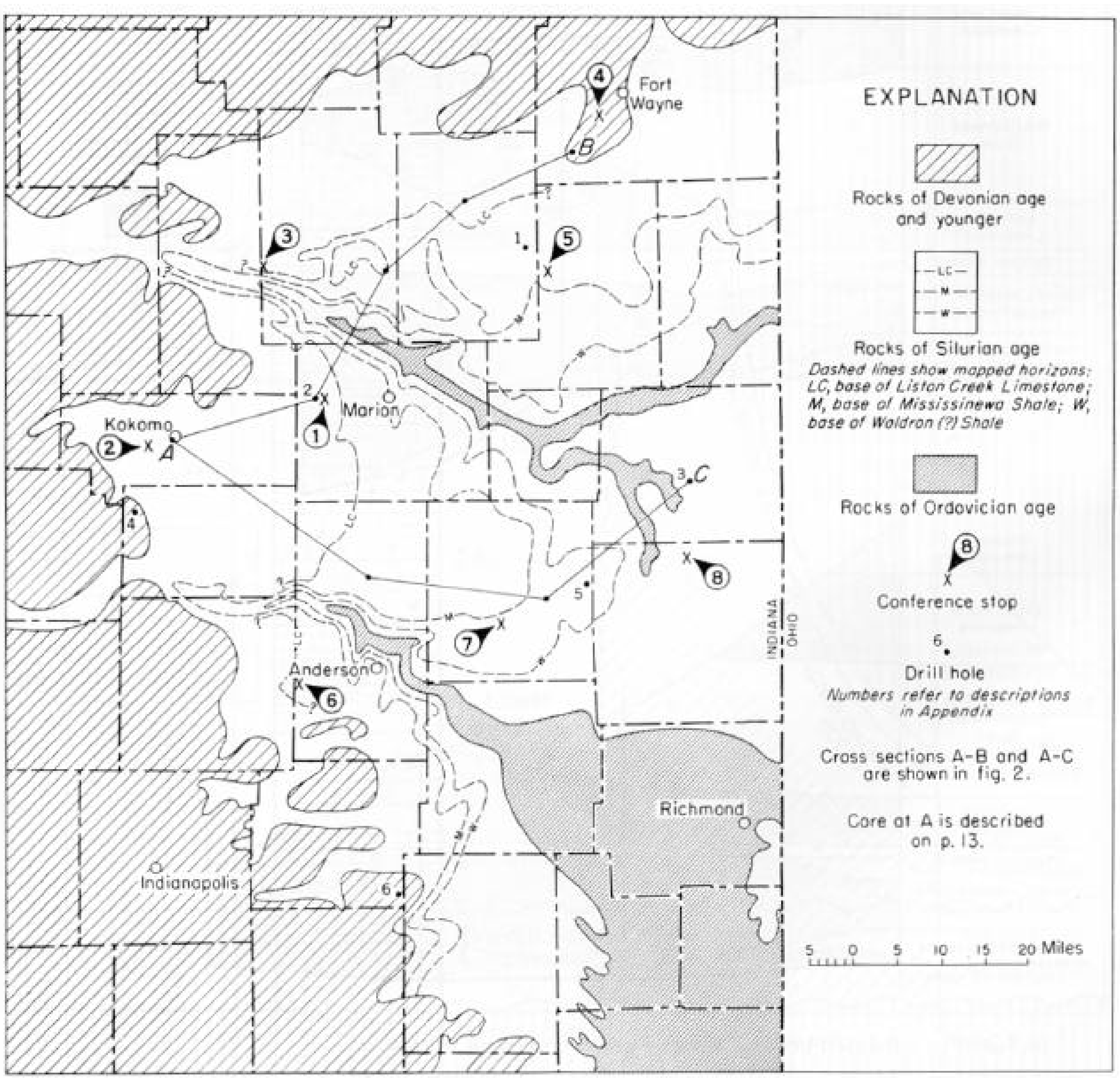


Figure 3. --Map showing generalized distribution of selected bedrock units in east central Indiana.

Log of core from Indiana Geological Survey drill hole no. 72, Markland Avenue Quarry, Kokomo (SW¼SW¼ sec. 36, T. 24 N., R. 3 E.). Altitude, 804 ft. Modified from log by Arthur P. Pinsak, October 1960.

	Depth (ft)
Silurian System, 385. 6 ft of rocks cored:	
Kokomo Limestone, 44.3 ft cored:	
1. Limestone, thinly banded, dolomitic; mostly tan, also gray, buff, yellow, light brown, and pale green where dolomitized; conspicuously and uniformly very thin bedded, dense to fine grained; has minor amounts of pyrite, manganese dioxide, clay, stylolites, vertical fractures, and secondary calcite; spottily petroliferous to 42.5 ft	6.9 to 51.2
Liston Creek Limestone, 74.3 ft:	
2. Limestone, cherty, dolomitic, mottled light tan-gray and dark gray, fine- to medium-grained, fossiliferous; has thin, indistinct, contorted laminae; has white to gray porcellaneous chert with relict limestone structure from 61.0 to 79.5 ft	51.2 to 79.5
3. Limestone, cherty, mottled tan and gray, medium grained becoming fine-grained and argillaceous 83. 0 to 87. 3 ft and fine-grained below 114. 2 ft; fossil fragmental; gray and green thin irregular argillaceous partings and blue-gray chert with relict limestone structure common; has minor amounts of pyrite, glauconite, and red fragments	79.5 to 125.5
Mississinewa Shale, 114. 5 ft:	
4. Siltstone, dolomitic, gray, faintly banded, fine-grained; has minor amounts of pyritic and carbonaceous organic fragments	125.5 to 146.0
5. Dolomite, silty, gray and green-gray with some red coloration at 150 to 154 and 162 to 180 ft, fine-grained, argillaceous, sparingly fossiliferous; interbedded with limestone on fine scale at 146 to 180 ft and becoming limestone at 197 to 210 and 215 to 240 ft; limestone is tan, fine grained to medium grained, fossil fragmental; most parts of unit faintly banded because of laminar concentrations of argillaceous dolomite	146.0 to 240.0
Lower Niagaran rocks, 122. 7 ft:	
6. Limestone, mottled gray and tan, dense, lithographic in part; sparingly fossiliferous; irregular shaly to clastic carbonate partings and secondarily filled fractures common; has few stylolites; unit occupies stratigraphic position of Louisville Limestone	240.0 to 282.5
7. Limestone, nodular, dense, tan-gray and tan; has many wavy black carbonaceous shaly partings wrapped around nodular components; unit occupies stratigraphic position of Waldron Shale	282.5 to 292.5
8. Limestone, conspicuously mottled tan and gray-tan; fine grained to medium grained, fossil fragmental with fine-grained matrix, sparingly stylolitic; secondary recrystallization and associated vugs common below 311. 5 ft; units 8 and 9 occupy stratigraphic position of Laurel Limestone and Osgood Formation	292.5 to 323.5
9. Dolomite, vuggy with associated fossil casts and molds; slightly mottled light gray and gray, porous; transitional to unit above	323.5 to 362.7

	Depth (ft)
Silurian System--Continued:	
Brassfield Limestone, 29. 8 ft:	
10. Dolomite, cherty, tan, saccharoidal; has green argillaceous partings and glauconitic intercalations near top; chert nodules are white and corroded with light blue-gray cores and relict limestone structure, common to 383. 2 ft; has shaly partings, small stylolites, and secondary recrystallization	362.7 to 386.5
11. Dolomite, similar to unit 10 but lacks chert and is more glauconitic	386.5 to 392.5
Ordovician System:	
Cincinnatian rocks, 14. 3 ft cored:	
12. Limestone, tan, medium-grained, fossil-fragmental; unit has intercalations of green fossiliferous pyritic shale	392.5 to 397.0
13. Limestone, gray-tan, fine-grained, fossiliferous; limestone is irregularly interbedded with green and gray fossiliferous shale	397.0 to 406.8

of southern Indiana. These pre-Mississinewa rocks above the Brassfield appear in the Kokomo core to be a rather monotonous 123-foot sequence of mottled limestones and dolomites. Yet as our observation of these rocks diverges southeastward and eastward through several other graduated control posts, we see that this interval includes a key marker or two along with some facies changes. In fact, thisintervalcontainsthemostvaluablekeystocorrelationacrosstheconference area.

We may run out one line of correlation, from the peculiarly distinctive nodular limestone with dark wavy shaly partings of unit 7 (Waldron position) of the Kokomo core, eastward through checkpoints in Tipton County (Appendix, section 4, unit 8), in Grant County (Appendix, section 2, unit 7), Delaware County (Appendix, section 5, unit 2), and Huntington County (Appendix, section 1, unit 4). (See also fig. 2.) The top of the nodular limestone in the cited sections lies 35 to 55 feet below the rocks identified here as Mississinewa Shale, and the bottom of the nodular limestone lies 70 to 80 feet above Brassfield rocks in the cited wells and at greater heights in the northeastern part of the conference area. Together with the subjacent and superjacent purer carbonate rocks, the slightly shaly interval, commonly 10 to 15 feet thick, can be recognized in cores and cuttings from throughout the conference area.

The overall aspect of the shaly interval varies somewhat from that of the 10-foot nodular wavy bedded limestone or dolomite mentioned above to dark argillaceous thin-bedded dolomitic limestone, to calcareous shale, and to alternating thin shales and dolomites. These varied aspects of this critical interval maybe seen in the expanded (35 to 45 feet) sections in the Grant County core (units 4 to 7), in the Delaware County core (units 2 to 4), in the sump of the Muncie Stone and Lime Co. quarry in Delaware County (stop 7), and in a Hancock County core (Appendix, section 6, units 4 and 5), taken from just south of the conference area.

Our line of sight from Kokomo along the shaly interval rises in altitude to the east and southeast, but the strata intervening down to Cincinnatian rocks do not vary appreciably in thickness. The altitude of this zone also increases southward from Allen County to Delaware County; this increase in altitude is accompanied by a southward thinning of the underlying rocks.

These spatial relationships result from the position of the conference area along and on the broad structural shelf that is the northwestern extension of the Cincinnati Arch and on the south edge (Allen County) of the Michigan Basin. Significantly, the shaly zone and adjacent strata do not wedge out or abut against older rocks at depth; they rise to the bedrock surface to make outcrop belts of successively older rocks eastward from Kokomo and southward from Allen County. Eastward thinning in our area does not appear to be significant, inasmuch as the lower Niagaran rocks have thicknesses between 105 and 140 feet in most of the conference area, and we assign at least 125 feet of rocks to the lower Niagaran sequence in the quarry and core cut on the property of Rockledge Products, Inc., near Portland, Jay County (Appendix, section 3). In the northern part of the conference area, however, these rocks have a thickness of more than 250 feet. Thus, the Silurian rocks cropping out in the eastern part of the conference area (Randolph and Jay Counties) are properly placed in the lower part of the Niagaran Series of Indiana and not in the upper part (Huntington Dolomite) as has been supposed generally.

The lower Niagaran equivalents of units 8 and 9 (Osgood and Laurel position) in the core from Kokomo are, elsewhere in the conference area, dolomite that is light colored to white, granular, commonly saccharoidal, porous, vuggy, and fossiliferous. This lithology is characteristic of the type Huntington Dolomite and of Huntington exposures in northwestern Indiana. We prefer here, however, to place the type Huntington much higher in the Niagaran section. Cherty phases of the lower Niagaran dolomites are common. (See sections in Appendix.)

The uppermost pre-Mississinewa rocks in the Kokomo core (unit 6, Louisville position) consist of 42 feet of strongly mottled lithographic to granular limestones. Nearly identical lithologies characterize the subsurface sections nearest Kokomo; elsewhere these rocks are commonly cherty and dolomitic as in the Delaware County core, as in the Muncie Stone and Lime Co. quarry (stop 7), and as in the Heller Stone Co. quarry (stop 5), where shale and sand also are intercalated.

These pre-Mississinewa-post-Brassfield rocks maybe traced southward from our observation post in Kokomo through the cited check points in Tipton and Hancock Counties to the exposures of lower Niagaran rocks in Shelby and Rush Counties. The Hancock County core, logged and correlated by John B. Patton in 1954, contains the key section wherein the Mississinewa Shale and Waldron Shale, with intervening Louisville Limestone, first were recognized as separate entities in one vertical sequence. Thus the type Waldron Shale finds its equivalents in units 4 and 5 in the Hancock County core, in unit 7 of the Kokomo core, and in outcropping rocks in the eastern part of the conference area (stop 7 for example). Correspondingly, the Laurel Limestone has equivalents in units 8 and 9 of the Kokomo core and in rocks exposed at stop 8; the northern extension of the Louisville Limestone is represented by the mottled lithographic limestone of unit 6 in the Kokomo core and by rocks in the quarries at stops 5 and 7, all below the stratigraphic position of the Mississinewa Shale.

At this point we find it convenient to recall that all of these rocks have been referred to “unnamed beds” or to the Osgood-Laurel section (Esarey and Bieberman, 1948), but we emphasize here the shaly interval between two carbonate units low in the Niagaran and the value of this trio for correlation. We should not presume to pick accurate upper and lower contacts of the Waldron Shale in all sections in the conference area except by arbitrary redefinition. We should like to excuse ourselves further, from appearing too old fashioned and vacillating in attempts at northern and southern Indiana correlations in Geological Survey publications, by reminding our readers that U. S. Highway 40 east of Indianapolis is not geologically sacred. Our suggestions are based partly on the relationships observed along the west flank of the northwestern extension of the Cincinnati Arch. And here at last we have discovered the full significance of the Devonian overlap, for Devonian rocks rest, from north to south, along the Silurian-Devonian contact, on progressively older Silurian rocks. U. S. Highway 40 lies nearly over one point where the Mississinewa Shale reaches minimum thickness, not by facies change but by post-Mississinewa erosion. (See Hancock County core.)

MISSISSIIVEWA SHALE

We have placed the lower contact of the Mississinewa Shale as low as possible in the Kokomo core in order to give the greatest consideration to the formidability of the drafted line on published correlation charts, but we can go no lower than 240 feet of depth. In picking the Mississinewa top at 125 feet we have considered the factthat the rocks exposedbelow the Kokomo Limestone in the city of Kokomo previously have been termed Mississinewa. Following the same practice here would require us to defend a considerably expanded Missiesinewa section without benefit of reef and perhaps would require that the structural feature called the Logansport Sag to have been active during Mississinewa time selectively. Admitting to some attraction for the chert in the rocks immediately below the Kokomo, we find it easier to call them Liston Creek Limestone.

The Mississinewa Shale in the Kokomo core is dolomitic limestone that is fine grained, argillaceous, and silty. The description is apt; “shale” hardly applies anywhere in the conference area. This formation constitutes another valuable key to correlation, and thus we recognize that its base rises in altitude eastward and intersects the bedrock surface in Madison, Grant, Wabash, Huntington, and Wells Counties. The basal contact lies 115 to 175 feet above Cincinnatian rocks in most of the conference area. The full thickness of the normal (interreef) Mississinewa generally is near 115 feet, although bioherms interfered with normal development of the lithology at some of the cited check points. Northward in Wabash and Huntington Counties the Mississinewa descends into the Michigan Basin, where it is part of a thicker section of Silurian rocks. The cited sections, however, evidently are not in the critical positions to show any thickening of the Mississinewa portions.

The top of the Mississinewa is well defined in its type area in Grant, Wabash, and Miami Counties, where a number of exposures show slabby-bedded cherty Liston Creek Limestone overlying Mississinewa Shale (fig. 5). We find, however, that our hesitation over the upper Mississinewa contact in the Kokomo core is comparatively minor, because eastward from Huntington County and southwestward from Madison County the type relationships become difficult to recognize. For example, Patton (1955, p. 16) noted that the Mississinewa has a purer and more dolomitic regional facie sin the northeastern part of the conference area. Furthermore, normal Mississinewa lithology may be unrecognizable in the vicinity of large biohermal masses or reefs. One example is provided by the Grant County core in which the upper 20 to 30 feet of the Mississinewa stratigraphic position is occupied by biohermal rocks. Many bioherms penetrate upward even into the Liston Creek Limestone. Outward from these structures the Mississinewa and Liston Creek are commonly further complicated by facies that are vertical and lateral intermediates to normal lithology. The flank rocks in the Standard Materials Corp. quarry (stop 6) and the rocks of unit 2 of the Huntington County core, described in the Appendix, are two examples. Cherty thin bedded limestones are one critical fades, and upon discovering them in isolated sections we cannot be sure whether they properly are considered lateral equivalents of type Mississinewa or type Liston Creek, as the rocks of unit 5 in the Tipton County core, for example.

The Mississinewa in one sense appears to be the host rock for most of the bioherms known in northern Indiana, at least in the lower parts of these structures, even for many of the so-called Liston Creek reefs. We are less certain about the contemporaneity of reef building and Liston Creek deposition despite appearances, and, as we show in the section on Huntington Dolomite, the same reef-building episode complicates our understanding of that formation.

LISTON CREEK LIMESTONE

The 74 feet of cherty argillaceous limestone called the Liston Creek Limestone in the Kokomo core and the lower rocks exposed in the Yeoman Stone Co. quarry (stop 2) at Kokomo are thicker bedded and more argillaceous than characteristic exposures of Liston Creek. Eastward from Kokomo the clay content decreases, and the formation consists of limestone that is gray to tan, fine grained to medium grained, fossil fragmental, cherty, and thin bedded. This lithology is seen not only at the type section but also in exposures in Madison, Grant, Wabash, and Huntington Counties. (See stops 1 and 3.)

The typical Liston Creek lithology appears to be an interreef facies of similar positions and similar relationships to the bioherms as the underlying Mississinewa, inasmuch as biohermal structures are flanked at many places by normal Liston Creek rocks at lesser altitudes than much of the reef rock. These structures thus have been called “Liston Creek reefs,” as for example the bioherm at Mill Creek (stop 3). That the Liston Creek has the expectable (under the assumed circumstances), strong, local facies development, we are not so certain; we do point out some gradational, flanking lithology at stop 3, and we recognize broader facies, as in Howard County. Furthermore, the Mississinewa-Liston Creek contact, while appearing to be a good one in the type area of these formations, suggests elsewhere that these formations should be considered jointly as the result of one geologic episode. In some wells characteristic Mississinewa and Liston Creek lithologies are observed to alternate. Within this framework some thought does hold (John B. Patton, personal communication) that the observed field relationships between the Liston Creek and the bioherms are the result of compaction and collapse and that the actual relationships are no closer than penecontemporaneous with the Liston Creek representing the later event. (See also Cumings and Shrock, 1928b, p. 138-145.)

The Liston Creek is 74 feet thick in the Kokomo core, and 103 feet of rocks are assigned to this formation in the Tipton County core that was taken from a slightly downdip position (toward the Illinois Basin). Eastward in the conference area exposed thicknesses hardly exceed 30 feet, and much or all of the thinning is due to erosion.

HUNTINGTON DOLOMITE

The Kokomo core contains no rocks in the upper part resembling Huntington Dolomite. We believe, however, that elsewhere in the conference area the type Huntington occupies approximately the position of the Liston Creek Limestone and Mississinewa Shale in the Kokomo core and that all the rocks called Huntington in different places are stratigraphically equivalent to nearly all the rocks in the core.

Thus the Niagaran rocks in the stratigraphic position of units 6 to 9 of the Kokomo core, as exposed in Randolph and Jay Counties, and the rocks represented at least partly by units 2 to 5, where they crop out near Huntington, are called Huntington Dolomite generally. (See fig. 1.) This formation consists of dolomite that is white, yellow, or gray, fine grained, saccharoidal, and evenly thin bedded to massive; less commonly it consists of limestone. Weathered exposures are grayer, thinner bedded, and more porous. A profuse fauna with Lockport and Guelph affinities was part of its basic understanding.

The Huntington of Comings and Shrock (1928b) and its fauna were mapped in two separated areas of outcrop. The eastern area is narrow at Huntington and broadens southeastward to include in Indiana all. of Jay and Randolph Counties. The western area begins on the Wabash River in Carroll County, includes exposures at Monon, Francesville, and Rensselaer, and continues beneath the drift to Chicago. The thickness of the Huntington was thought to be about 150 feet in the type area and about 450 feet near Fort Wayne (Comings, 1930a, p. 184). The combined thickness of exposed and cored Huntington lithology in the Rockledge Products, Inc. quarry near Portland, Jay County, is 125 feet, but we also correlate the same rocks with a position low in the Niagaran Series. The present conference area embraces only the eastern area of outcrop of the Huntington as described. The type section along Little Wabash River east of Huntington is not readily accessible to a large group, but characteristic lithology, at a lower stratigraphic position, can be observed in the H and R Stone Co. quarry at Ridgeville, Randolph County (stop 8).

Chemical analyses have shown that the Huntington commonly has an almost theoretical dolomite composition, whether the formation was tested at locations where it is horizontally bedded, as at stop 8 for example, or at locations where it comprises biohermal structures.

KOKOMO LIMESTONE

Perhaps the most striking lithology in the Kokomo core is that of the uppermost 44-foot unit which certainly corresponds to the upper rocks in the Yeoman Stone Co. quarry (stop 2) 2 miles southwest of the cored site. The thinly laminated character is distinctive of this formation; intraformational corrugation as described by earlier authors is not apparent at either of our present points of observation.

This lithologic unit is traced northward from Kokomo through exposures and deep wells into Fulton and Marshall Counties in the southern part of the Michigan Basin. It appears to be associated with the structural feature known as the Logansport Sag, which terminates the northwestern extension of the Cincinnati Arch. The formation does not appear to extend eastward along the south edge of the basin into the Fort Wayne area (stop 4), where other laminated rocks (Jeffersonville Limestone? of Devonian age) have been called Kokomo or its presumed equivalent, Greenfield Dolomite of Ohio usage.

HISTORY OF THE STRATIGRAPHIC CONCEPTS AND NOMENCLATURE

PRE-MIS81SSINEWA ROCKS

Pre-Mississinewa Silurian rocks of northern Indiana have received little attention in the past. If these rocks aid not appear at the surface, as has generally been assumed (“not exposed,” Swartz and others, 1942), we could easily dispense with them for purposes of the conference. (See fig. 4.) We have endeavored to show, however, that large areas of eastern Indiana are immediately underlain by rocks in the lower part of the Indiana Niagaran section (fig. 1).

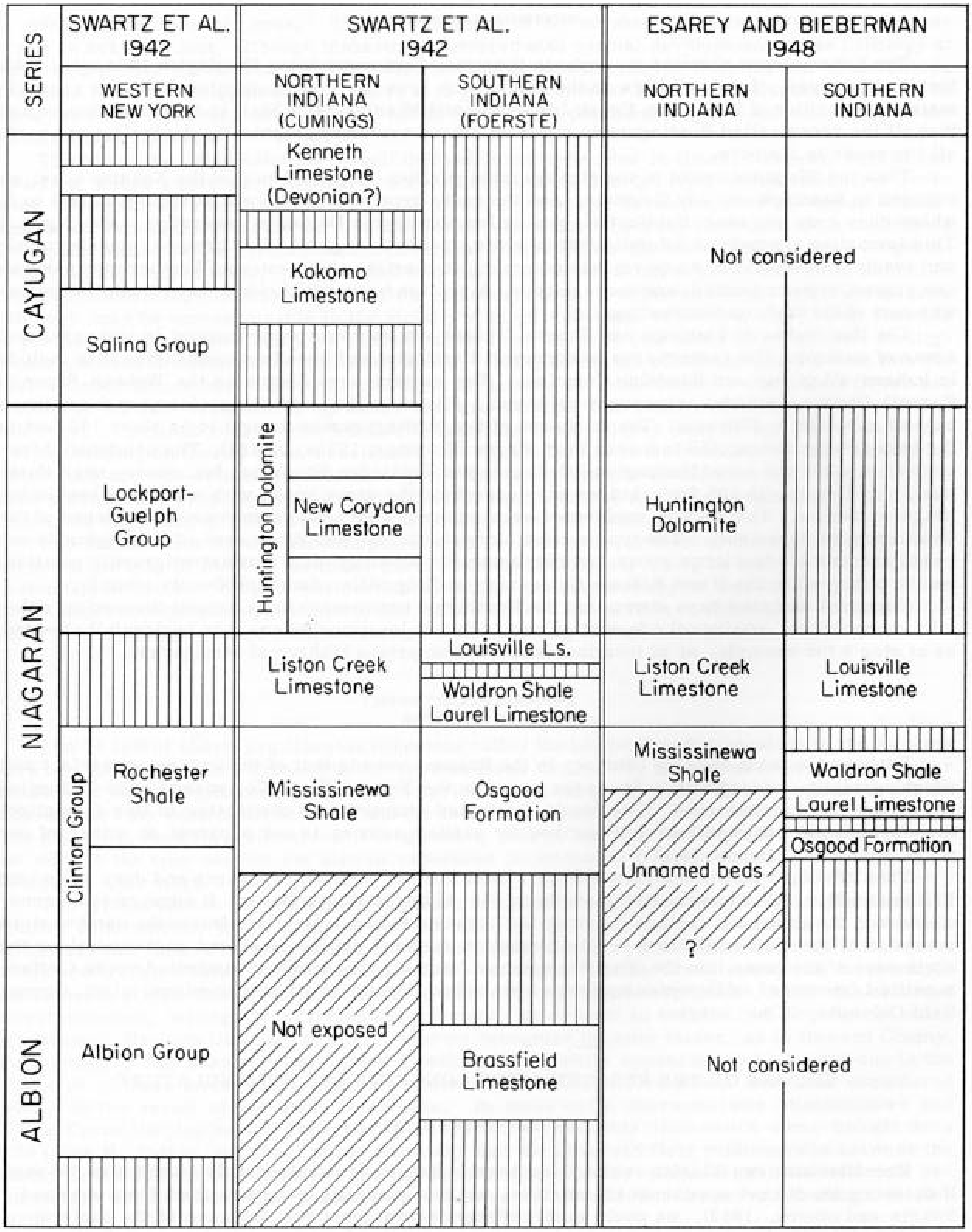


Figure 4. --Earlier correlations of the Silurian rocks of northern and southern Indiana and western New York.

Brassfield Limestone.--We must not presume through default that the lower Niagaran rocks take us to the base of the Silurian rocks. Furthermore, we shall see how earlier failure to get to the bottom of the Mississinewa and Niagaran resulted in nomenclatural difficulties, and we must not repeat the failure in regard to the Silurian.

"Brassfield" had become an exceedingly popular name among stratigraphers, some of whom speak of its remarkable ease of correlation over wide areas of the Midwest (Freeman, 1951, p. 8-9). Although Foerste (1906) did not mention chert everywhere in the type area in eastern Kentucky, this criterion, along with glauconite, had become an important key to Brassfield recognition in the Indiana subsurface. Where chert is absent from basal Silurian rocks, as in Grant County, we are inclined to speak of erosion or nondeposition (Esarey and Bieberman, 1948, p. 25). Generally not recognized is the presence of as much as 25 feet of noncherty carbonate rocks of Silurian age below the cherty Brassfield rocks in the conference area. These rocks, although overlooked, have been included in the Brassfield. By means of its chert the Brassfield is traced into the Illinois Basin where it is associated upward in some sections with similarly cherty Laurel Limestone. On the west side of the basin certain rocks have been assigned to the Brassfield by faunal means, and the noncherty rocks below the Brassfield have been named the Edgewood and Girardeau Limestones. Although we may choose to pick the Indiana subsurface Brassfield by whatever convenient means are available, its correlation is rather tenuous.

Lower Niagara rocks.--All may not agree that the lowermost Niagaran rocks are unnamed, for Cumings and Shrock (1927, p. 72) defined the Mississinewa Shale as extending "from the base of the yellow (Liston Creek) limestone above, downward as far as typical development continues." Later the same authors (1928b, p. 57) stated that the "formation includes the strata lying between the base of the Niagaran and the base of the overlying cherty limestone," but this redefinition was tentative. The original definition, "downward as far as the argillaceous character continues," was resumed on page 61 of the later publication, and the redefinition was to be applied at such time as lithology of the lower rocks should be determined. Should that lithology be carbonate, then "formation" was to replace "shale" as the surname of "Mississinewa."

Esarey and Bieberman (1948, p. 15, fig. 4) noted this unsatisfactory condition and restricted the Mississinewa to the original definition as a shaly unit. They referred to the carbonate rocks below the Mississinewa in northern Indiana as "unnamed beds," but they also correlated the "Osgood-Laurel section" (p. 25-26) of southern Indiana with all the subsurface post-Brassfield and pre-Mississinewa rocks penetrated by wells in the field conference area.

Lowenstam (1949, p. 13) considered that the St. Clair Limestone of Arkansas extends across the Illinois Basin into Indiana and the Michigan Basin, that the St. Clair is the lowest Niagaran formation in the Illinois Basin, and that the Laurel Limestone is a tongue of that formation. The term "Huntington Dolomite" also has been applied to the unnamed rocks in their area of exposure in Randolph and Jay Counties as has the term "Cedarville Dolomite"; "New Corydon" has been applied to their exposures in Adams and Jay Counties. (See discussion under "Huntington Dolomite and New Corydon Limestone.")

Our present suggestions for correlation of the lower part of the unnamed beds with the Osgood Formation and Laurel Limestone, the upper part with the Louisville Limestone, and the intervening shaly dolomite with the Waldron Shale must now have consideration. Altogether, we seem to have an overabundance of names for the lower Niagaran rocks without borrowing from the Michigan Basin or elsewhere.

MISSISSINEWA SHALE

The Mississinewa Shale was named by Cumings and Shrock (1927, p. 72) from exposures along the Mississinewa River ("River of Great Stones") in Grant, Wabash, and Miami Counties. No type section has been designated for the formation. Seventy-five feet of this formation crops out at Wabash, but nowhere is the Mississinewa exposed entirely. The commonly accepted definition, as stated in the preceding discussion, restricts this formationto the argillaceous rocks below the Liston Creek Limestone and above the more calcareous lower Niagaran strata.

Cumings and Shrock (1927) considered that the age of the Mississinewa is late Rochester or early Lockport, and later Cumings (1930a and b; 1941) stated that the Mississinewa is "clearly Rochester and not Lockport." The bases for these correlations are the Mississinewa graptolites and Cumings' correlation of the overlying Liston Creek Limestone with the Louisville Limestone (pre-Lockport) of southern Indiana. Esarey and Bieberman (1948) agreed with Cumings' assignment and further correlated the Mississinewa with the Waldron Shale of southern Indiana.

Lowenstam (1949, p. 25) considered that the Mississinewa Shale of our conference area is a still-water facies of his interreef Thorn Group in the upper part of the Niagaran Series. The Thorn type area is near Chicago, and the group was defined by Lowenstam to include "all of the Niagaran formations exposed in the Chicago region, in southeastern Wisconsin, and in the Wabash Valley of Northern Indiana."

For the purposes of this conference we make a few suggestions concerning the earlier concepts. (1) We assign rocks formerly termed Mississinewa in the western part of the conference area to the Liston Creek Limestone. Thus, the surname "Shale" takes on renewed significance where, in Howard and Miami Counties, past exception had been made to provide for a Mississinewa carbonate facies. (2) The Mississinewa is a good correlative guide, and its competence is improved under item 1 above. We recommend, however, its disassociation from the Waldron Shale and indicate a higher correlative position in the standard section. (3) We refer to the Mississinewa as the host formation for the reefs, although we might be hard pressed at this point to prove from a sedimentational viewpoint that the Mississinewa is not a reef-controlled facies. The fact remains, however, that the normal (interreef) Mississinewa and similar rocks intermittently above can be traced over a broad area in central and northern Indiana along the flanks of the northwestern extension of the Cincinnati Arch. Any local reconstitution of the upper Niagaran stratigraphic nomenclature probably ought to recognize the Mississinewa in a major role at least as the principal means of recognizing a group of formations consisting of the lower argillaceous interreef unit, the overlying locally dolomitic or argillaceous interreef Liston Creek Limestone, and reef and intermediate facies. The Huntington Dolomite is in bad shape nomenclaturally, and the suggested arrangement would provide for the upper Niagaran rocks assigned to that formation. (See the sections on Liston Creek Limestone and Huntington Dolomite.)

LISTON CREEK LIMESTONE

The Liston Creek Limestone was named by Cumings and Shrock (1927, p. 75) from exposures along Liston Creek in southwestern Wabash County (fig. 5). Originally the formation did not include the Red Bridge Limestone Member at the base. This sequence was renamed the Liston Creek Formation by these authors (1928b, p. 71), however, and was redefined to include the Red Bridge as a "rather local bed." As thus defined, the formation extends from "the top of the Mississinewa shale (to) the base of the overlying saccharoidal Huntington dolomite.".

The Red Bridge of Cumings and Shrock is a yellowish to reddish-brown argillaceous limestone, commonly in a single bed from 1 to a few feet in thickness and found only in Wabash County. The Indiana Geological Survey does not use the term "Red" and also has reverted to the original "Liston Creek Limestone." We note also that the contact of the Liston Creek and "overlying Huntington dolomite" has not been observed, and, as discussed farther on, we find ourselves in the uncomfortable position of defending the Liston Creek as the uppermost formation of the Niagaran Series.

Among earlier workers Kindle in Kindle and Breger (1904, p. 407) proposed the name "Noblesville dolomite" for probably "not less than 100 feet" of thin-bedded dolomite with a Lockport fauna in Hamilton County. Cumings and Shrock (1927, p. 77) abandoned the name in favor of Liston Creek, because the type section and several other exposures of the Noblesville are in nonrepresentative reef rock. Furthermore, the type section had been inundated in the city reservoir. They correlated the Liston Creek with the Lockport Dolomite of New York and Waukesha Limestone of Illinois and Wisconsin. They further noted difficult-to-explain Guelph species in so-called Liston Creek reefs but nevertheless leaned heavily toward correlation with the Louisville Limestone, especially because of common species of corals. Cumings (1930a and b) became firmly convinced of the Louisville correlation and made special note of the "Coral Beds" (Liston Creek, Waukesha, Louisville, and Manistique, restricted) as one of the moat reliable markers around the Michigan Basin. The coral beds collectively were assigned a pre-Lockport position in the standard section, at which point they have remained to this time so far as the Indiana portion of the "Coral Beds" is concerned (Swartz and others, 1942; Esarey and Bieberman, 1948).

We suspect, however, that Lowenstam (1949) did not agree with such a position for the Liston Creek, as he considered that the Niagaran formations of the upper Wabash Valley, without naming all of them individually, belong in his interreef Thorn Group in the upper part of the local Niagaran section. Our present concept of the Liston Creek does fit in nicely with Lowenstam's work, and we think that it correlates well up in the Lockport-Guelph Group.

HUNTINGTON DOLOMITE AND NEW CORYDON LIMESTONE

The term "Huntington stone" was used in an informal way in 1878 by E. T. Cox for the rock quarried for lime in Huntington County, Ind. Kindle in Kindle and Breger (1904, p. 408) acknowledged Cox's use of the term "Huntington stone" and suggested that "it will be convenient to designate the beds exposed in the Huntington quarries as the *Huntington limestone*."

Cumings and Shrock, in their 1927 publication on Silurian reefs of northern Indiana, did not consider the Huntington as a separate formation but preferred to regard it and the Noblesville Dolomite (1927, p. 76 and 77)". . , as phases of the reef rock. . ." of other formations. They

Figure 5. --Type section of the Liston Creek Limestone on Liston Creek, southwestern Wabash County (NE¼SW¼ sec. 24, T. 26 N., R. 5 E.). The Liston Creek overlies the Red Bridge Member of Cumings and Shrock (1927) (rim of falls), which in turn overlies the Mississinewa Shale.

stated that “in a few outcrops a druzy brown or yellow very fossiliferous dolomite is associated with the Liston Creek. The exact position of this formation is not certain. It may represent an overlying formation distinct from the Liston Creek, or it may be only a local development of it, found only adjacent to the coral reefs .... Each of these exposures is near the flank of a coral reef, and it is likely that the prolific fauna found in the formations represents the inhabitants of the waters near the reef.”

One year later Cumings and Shrock (1928b, p. 95) were firmly convinced that the Huntington should be recognized as a good formation superjacent to the Liston Creek. They renamed it the “Huntington dolomite” and relocated Kindles "type section” at the Huntington quarries to nearby exposures along Little Wabash River, because “. . . several distinct formations complicated by a great coral reef plexus are now exposed in the quarries at Huntington.” The new type section was described as: “ . . the exposures of yellowish to grayish saccharoidal dolomite along the dredged rock channel of Little River,” from the NE¼SW¼NE¼ sec. 13, T. 28 N. , R. 9 E. , “eastward nearly to the west line of Sec. 8, T. 28 N., R. 10 E., where a cherty formation [the New Corydon Limestone] comes in above the Huntington dolomite.” They (p. 102) considered that the Huntington “unites with the Springfield-Cedarville sequence to the east and with the Racine-Guelph sequence (Racine-Port Byron in Illinois) to the west and northwest.”

Busch (1939aand b) restricted the Huntington in west-central Ohio and northern Indiana to that part of the formation which contains a Guelph fauna. “The lower 43 feet of the 70-foot section of Huntington dolomite, as exposed at Ridgeville [near stop 8], Randolph County, Indiana, is thus relegated to the underlying Cedarville formation whose total thickness is 95 feet.”

John B. Patton began a coring program, which, together with conferences with D. F. Bieberman and H. A. Lowenstam, led to our present understanding of the Huntington and associated rocks. Patton (1949, p. 12) suggested that much of the exposures termed Huntington are Liston Creek and Mississinewa in age and that in fact the so-called Huntington of Adams, Jay, and Randolph Counties might be surface exposures of the unnamed subsurface beds overlying the Brassfield and underlying the Mississinewa. Thus all is not well with the Huntington. The rocks of the newer type section, along Little Wabash River, probably are reef-core and reef-flank beds, possibly of the same reef plexus referred to when Kindles original type section was abandoned. We also remind our readers that the Liston Creek has been identified throughout the area surrounding Huntington, some in intimate association with the great reef plexus, but the Liston Creek is seen nowhere to underlie rocks called Huntington.

Thus, unable to show, agreeing with Cumings and Shrock's opinions in 1927, that any part of the Huntington lies above or is younger than the Liston Creek, we consider abandoning the term “Huntington.” “Huntington” is the oldest Niagaran name still used in northern Indiana, but confusion in the type sections and nearly synonymous application with “Niagaran” have greatly depreciated the term. “Huntington facies” may be more appropriate informal usage. (Our conferees will appreciate that the field conference committee nearly came to blows, before we realized that our difficulties were only semantic, with “Huntington” being all things to all men.)

The New Corydon Limestone was named by Cumings and Shrock (1928a, p. 588) from exposures in the vicinity of New Corydon, Ind. They stated (1928b, p. 115) that it is exposed at only three localities: “. . . in the vicinity of New Corydon; at and near Linn Grove; and two and one-half to three miles east of Huntington along Little River." They also indicated that rock in the Bowers Quarry at Decatur, previously noted by Kindle, might also be of New Corydon age but that the rock there was no longer visible.

In quarries at New Corydon the contact of the New Corydon Limestone with the underlying Huntington Dolomite is sharp, but along Little Wabash River “. . . the Huntington formation grades upward into the New Corydon so graduallythat the contact is difficult to locate. Only the presence of chert indicates that the contact has been passed.”

These authors expressed “. . . considerable doubt about the exact age...” of the exposures at Linn Grove. They also stated that “we know of no formation like the New Corydon in Ohio, and so far as we have observed, it is not present in the western part of Indiana.” They stated of the formation in general that “we do not know what lies immediately above the New Corydon limestone, but it is likely that the Kokomo limestone or its eastern equivalent, overlies the formation in eastern Indiana.”

The New Corydon consists of a few feet to 20 feet of “irregularly bedded, brown cherty layers of impure limestone with intercalated carbonaceous partings. It has a conspicuous blocky nodular appearance on weathered surfaces.”

Two years later Cumings (1930a, p. 183-190)indicated that the New Corydon was only a member midway in the Huntington Dolomite. He extended the area of occurrence of the New Corydon by identifying it in a deep well at Fort Wayne. The New Corydon Limestone was included within a 450-foot total section of Huntington Dolomite and was determined to be about 100 feet thick.

The term "New Corydon" was applied in western Ohio by Busch (1939a and b), who ignored Cumings' 1930 interpretation of the New Corydon as a member within the Huntington. Busch considered that the unit overlies the Huntington, which he restricted to those rocks containing a Guelph fauna. Patton (1949, p. 12) suggested that the New Corydon is a more dolomitic eastward facies of the cherty upper part of the Liston Creek and that its Lockport fauna is not compatible with its higher assigned stratigraphic position.

Specifically here, we believe that the New Corydon exposures along Little Wabash River east of Huntington do represent an off-reef near-normal lithology of the Liston Creek; the type exposures in Adams County, however, are below the stratigraphic position of the Mississinewa Shale and possibly are as low as the Laurel Limestone. Within this range, type New Corydon rocks resemble the cherty rocks at Muncie (stop 7), which are in the Louisville stratigraphic position. Altogether, "New Corydon" is in low esteem, and, until such time as the type exposures may be correlated properly and the term redefined, we shall not use the term.

KOKOMO LIMESTONE

The Kokomo Limestone is one of the most interesting and perplexing formations in Indiana. Its eurypterids have lent it an international reputation, and its sedimentary and structural characteristics have roused several discourses on the depositional history. In spite of this attention, its proper correlation is in doubt today, as those persons who prefer either a Niagaran, Cayugan, or Devonian assignment may find support for their cause. We here should like to expose this formation to further question by removing the necessity in part of the field conference area for the major disconformity at its base that has been suggested by some authors.

The most recent formal definition of the Kokomo Limestone is by Cumings and Shrock (1927, p. 76-77), who, following a suggestion from A. F. Foerste, restricted the formation to the lower of two members as originally defined by Foerste in Hopkins (1904, p. 33). Foerste applied the name to the eurypterid beds (below) and the overlying brachiopod bed (Kenneth Limestone) at Kokomo. The eurypterid beds were also knownas the "Waterlime beds," and Foerste stated that this "division of the Cayugan, has been definitely identified... by means of its fossils only at Kokomo," which "fossils suggest the equivalence to the Bertie or Lower Waterlime bed, in the lower part of the Cayugan." Cumings and Shrock (1928b, p. 118) considered that the Kokomo "includes the 45 to 50 feet of finely-laminated, argillaceous limestone lying between the Mississinewa shale below and the cherty Kenneth limestone [brachiopod bed] above, as exposed in the Markland Avenue quarry at Kokomo; and the 45 to 50 feet of similar stone lying below the cherty Kenneth limestone in the Big Blue Hole and Kenneth quarries west of Logansport. Owing to the disconformity at the base of the Kokomo the limestone overlaps several different formations."

The type section in the Markland Avenue Quarry, north of the Continental Steel Corp. plant, is being obliterated by slag filling and is nearly inaccessible. Both the lower and upper contacts are no longer exposed. Thus the core from Indiana Geological Survey drill hole no. 72 (see p. 13) that was cut on the quarry site and that is displayed at conference headquarters may serve as a type, and other exposures in Kokomo remain as good reference sections. (See Yeoman Stone Co. quarry, stop 2.) The coring unfortunately did not penetrate the overlying Kenneth Limestone, but a thickness of 44 feet of thin-bedded limestone shows that nearly all of the Kokomo is represented.

UNCONFORMITY AT THE BASE OF THE KOKOMO?

We consider here that the disconformity described at the base of the Kokomo is still a matter of conjecture. The evidence for it may be considered in three categories: (1) paleontologic, (2) lithologic and stratigraphic, and (3) local sedimentary and structural characteristics along the lower contact of the Kokomo.

Eurypterids provided early means of faunal correlation with the standard Silurian section. They were said to be variously of Lockport, Salina, and Bertie age in the Niagaran and Cayugan Series. Later, Cumings (1930b, p. 206) listed 18 new species, mostly brachiopods and corals, from the Kokomo at Logansport and stated that the fauna "confirms the long suspected correlation . . . with the Bertie-Akron of New York and Ontario and the equivalent Greenfield dolomite in Ohio." Kjellesvig-Waering(1958, p. 295) recently concluded that the Kokomo eurypterid fauna, comprising five species according to the latest taxonomic revisions, compare most closely with Middle Ludlovian (correlated with the Cayugan) forms from England. The Kokomo fauna, however, is rather distinct from others in North America and has allowed North American paleontologists leeway in suggesting ages as late as Devonian.

At an early date, the Kokomo (Waterlime) had been associated, by lithologic character, with the lower Helderberg rocks (Devonian age), and with the so-called Bertie Lower Waterlime of New York and Ontario. In Indiana stratigraphic evidence for the disconformity consists of local identification of the underlying beds variously as Mississinewa, Liston Creek, and Huntington. For example, Cumings and Shrock identified the rocks below the Kokomo at Kokomo and at Peru, Miami County, as Mississinewa. We note, however, that the Mississinewa of Cumings and Shrock (1928b, table of analyses, p. 57) at these localities departs from its normal composition and takes on a considerable content of carbonate. We here assign these rocks to the Liston Creek Limestone and thus remove the nomenclatural necessity for an unconformity in this part of the conference area.

The lower contact of the Kokomo photographed by Cumings and Shrock in the Markland Avenue Quarry in Kokomo appears sharp but no more so than many "conformable" contacts, the Mississinewa-Liston Creek contact, for example. The contact of the Kokomo on the lower rocks in the Yeoman Stone Co. quarry (stop 2) appears to be uniformly planar and transitional through 1 foot (or less) of strata. Possibly the lower contact may be observed in the May Stone and Sand, Inc. quarry (stop 4), where one present school of thought considers that the Kokomo is represented by rocks labeled "Devonian" here, and this school supports the idea of unconformity.

Perhaps the most convincing structural evidence for the unconformity consists of exposures along the Wabash River west of Logansport, Cass County. There the Huntington Dolomite is exposed as "remnants" with Kokomo Limestone "abutting against the Huntington" at altitudes as low as 40 to 50 feet below the highest Huntington rocks. Unfortunately, the contact itself is not visible.

The chairman of the field conference committee, like the stratigraphers, is struck with the conspicuous thinly laminated character of the Kokomo. In fact, he concludes that it spontaneously elicits strong, either positive or negative, opinions on its correlative value and that it does so to such an extent that the chairman has been unable to extort any agreement from the stratigraphers regarding the Kokomo's stratigraphic position. Thus we ride to Fort Wayne to see one of the most spectacular exposures in Indiana--an exposure which would add little of a positive nature to this conference on Silurian stratigraphy should all the rocks of questionable age there prove to be Devonian.

Jointly, we are not sure that the Kokomo is correlated properly even to Logansport, where some Indiana stratigraphers prefer to approach the laminated rocks from the Devonian side and to assign them to the Jeffersonville Limestone. They consider that our difficulties arise from a lack of appreciation for the Devonian overlap which cuts out the Jeffersonville coral zone, the Geneva Dolomite, and the Pendleton Sandstone from some areas. The same reasoning applies to the upper rocks exposed at Fort Wayne, where some Devonian rocks are present, but we are not prepared jointly to say how much or what relationship they have to the Kokomo Limestone.

KENNETH LIMESTONE

The Kenneth Limestone, as we learned above, is associated with the Kokomo stratigraphically and geographically. Cumings (1930b, p. 208) drew attention to the similarity of its fauna to that of the Keyser Group (upper Cayugan) of the eastern United States, but later the Kenneth was mapped as Devonian in age (Logan, 1932). The Indiana Geological Survey presently recognizes its age as Devonian (Patton, 1956). The idea of unconformity at the base of the Kenneth has considerable support. The Kenneth is exposed in the western part of the field conference area, but it is not present at the Kokomo stop; possibly equivalent strata labeled "Middle? Devonian" may be seen in the May Stone and Sand, Inc. section (stop 4).

THE FOSSIL EVIDENCE

To the possible delight of some stratigraphers, we have risked offending paleontologists up to this point by mostly ignoring the fossil evidence. The inherited stratigraphic framework in which we suggest considerable revision does have a great body of paleontologic data that was offered as binding for that framework. The Silurian fossils of northern Indiana have indeed become so much a part of classic paleontology that the front they present appears formidable, if not inviolable. If we examine the details of that front, however, we can penetrate it and yet preserve a great deal of respect for its component parts. We attempt here to show that the newer stratigraphic interpretations generally are not incompatible with the paleontologic scheme and that in some details the two lines of evidence provide mutual support. We cannot pretend, however, to reconcile all points of conflict.

Silurian faunal correlations of northern Indiana have hardly passed beyond the stage of correlation by percentage-of-common-species method. Reef ecology is considered in some earlier reports, but the magnitude of the ecologic impact when stacked against the fine scale of rock division is largely unknown. We shall be guilty here, however, of applying percentages to show how certain faunas support our newer stratigraphic interpretations.

The Niagaran and Kokomo fossil lists must now be scrutinized in terms of their geographic components. These lists have been carried along and expanded from author to author through changes in paleontologic and stratigraphic terminology, or in the words of the State Geologist, "here is an example of pushbroom paleontology." A part of each list includes fossils from rocks that were first correlated with a type by means of lithostratigraphy and the fossils then added to the list. Species from some of the rocks here reassigned support that reassignment better than they lent distinction to the presumed faunal type. Thus, some local fossil collections never were an essential part of a particular fauna. We have compiled table 1 in order to discharge our minimum responsibility to paleontologists for having recorrelated many of the collecting sites.

Lastly, we observe generally that the Niagaran lists, in addition to being lists of species, are compilations of diverse paleontologic judgments. Many authors, as well as differing criteria, are involved in the recognition of the separate biologic components of the present lists. Thus, some species of the earliest authors undoubtedly would not be on given lists if these species were subjected to the more rigorous definitions of later authors.

Table 1.-*Revised stratigraphic positions of published faunas from the Silurian rocks of northern Indiana listed by geographic locality*

Locality	Earlier assignment	Present assignment
Adams County:		
J. W. Karsch quarry, SW¼SW¼ sec. 31, T, 25 N., ft. 15 E.	New Corydon (C&S, C)[1]	pre-Mississinewa, Laurel? position
Smith & Baker quarry, SW¼sec. 32, T. 25 N., R. 15 E.	New Corydon (C&S, C)	pre-Mississinewa, Laurel? position
	Huntington (C&S)	pre-Mississinewa Laurel? position
Carroll County:		
Camden, NW¼NW¼ sec. 30, T. 25 N., R. 1 E.	Huntington (C&S)	upper Niagaran
Delphi, secs. 19, 20, 29, and 30, T. 25 N., R. 2 W.	Huntington (C&S)	upper Niagaran
Little Deer Creek (same as Camden)	Niagara limestone (K&B)[2]	upper Niagaran

Table 1.-*Revised stratigraphic positions of published fauna from the Silurian rocks of northern Indiana listed by geographic locality*-Continued

Locality	Earlier assignment	Present assignment
Cass County:		
Georgetown, Ts. 26 and 27 N., R. 1 W,	Huntington (C&S)	upper Niagaran
Logansport, T. 27 N., Rs. 1 E. and 1 W.	Kokomo (C)	Kokomo?
	Huntington (C&S)	upper Niagaran
Delaware County:		
Muncie, Center sec. 20, T, 20 N., R. 10 E:	Liston Creek (C&S)	pre-Mississinewa, Louisville? position
Yorktown, S½ sec. 14, T. 20 N., R. 9 E.	Mississinewa (C&S)	pre-Mississinewa?
	Mississinewa reef (C&S)	pre-Mississinewa?
Grant County:		
Marion, SW¼ sec. 31, T. 25 N., R. 8 E.	Liston Creek (C&S)	lower Mississinewa?
Hamilton County:		
Connors Mill, secs. 9 and 16, T. 19 N., R. 5 E.	Liston Creek reef (C&S)	upper Niagaran
Fishersburg, sec. 20, T. 19 N. , R. 6 E,	Noblesville dolomite (K&B)	upper Niagaran
Helms Mill, sees. 5 and 6, T. 17 N., R. 6 E.; sec. 32, T. 18 N., R. 6 E.	Noblesville dolomite (K&B)	upper Niagaran
Howard County:		
Kokomo, NE¼ sec. 35, T. 24 N., R. 3 E.	Kokomo (C&S, C)	Kokomo
	Mississinewa (C&S)	Liston Creek
Huntington County:	New Corydon (C)	Liston Creek
Huntington, sec. 8, T. 28 N., R. 10 E.		
Huntington, secs. 7 and 18, T. 28 N., R. 10 E.	Liston Creek (C&S)	Liston Creek
Little River, sec. 8, T. 28 N., R. 10 E,	New Corydon (C&S)	Liston Creek
Little River, sees. 7, 8, and 18, T. 28 N., R. 10 E.	Huntington (C&S)	type Huntington, upper Niagaran

Table 1.-*Revised stratigraphic positions of published fauna from the Silurian rocks of northern Indiana listed by geographic locality*-Continued

Locality	Earlier assignment	Present assignment
Huntington County--Continued:		
Markle, Wildcat Reserve No. 37, T. 27 N., R. 10 E.	Liston Creek reef (C&S)	upper Niagaran
	Mississinewa (C&S)	Mississinewa
Jay County:		
Jay City, sec. 5, T. 24 N., R. 15 E.	Huntington (C&S)	pre-Mississinewa, Laurel? Position
Madison County:		
Lapel, sec. 28, T. 19 N., R. 6 E.	Liston Creek reef (C)	Mississinewa
Pendleton, sec. 20, T. 18 N. , R. 7 E.	Noblesville dolomite (K&B)	upper Niagaran
Miami County:		
Bunker Hill, secs. 19, 29, and 30, T. 26 N., R. 4 E.	Niagara limestone (K&B)	upper Niagaran?
Little Pipe Creek, Peru, SW¼ sec. 29, T. 27 N., R. 4 E.	Mississinewa (C&S)	Liston Creek
Peoria, sec. 4, T. 26 N., R. 5 E.	Liston Creek reef (C&S)	upper Niagaran
Peru, T. 27 N., R. 4 E.	Liston Creek reef (C&S)	upper Niagaran
Peru, sec. 20, T. 27 N., R. 4 E.	Mississinewa reef (C)	upper Niagaran
Seven Pillars, Reserve No. 10, T. 26 N., R. 5 E.	Liston Creek (C&S)	Liston Creek
Randolph County:		
Fairview, NE¼ sec. 11, T. 21 N., R. 12 E.	Huntington (C&S)	pre-Mississinewa, Louisville? or Laurel? position
Maxville, sec. 20, T. 20 N., R. 13	E. Huntington (C&S)	pre-Mississinewa, Laurel? position
Ridgeville, SW¼ sec. 7, T. 21 N., R. 14 E.	Huntington (C&S)	pre-Mississinewa, Laurel? position
Wabash County:		
(general)	Liston Creek (C&S)	Liston Creek and others?
Lagro, T. 28 N., R. 7 E.	Mississinewa (C&S)	Mississinewa

Table 1.-*Revised stratigraphic positions of published fauna from the Silurian rocks of northern Indiana listed by geographic locality*-Continued

Locality	Earlier assignment	Present assignment
Wabash County--Continued:		
Red Bridge, S½ Reserve No. 26, T. 26 N., R. 6 E.	Liston Creek (C&S)	Liston Creek
	Mississinewa (C&S)	Mississinewa
Wabash, T. 27 N., R. 6 E.	Liston Creek reef (C&S)	upper Niagaran
	Liston Creek (C&S)	Liston Creek
	Mississinewa (C&S)	Mississinewa
Wells County:		
Bluffton, T.26 or 27 N., R. 12 E.	Liston Creek reef (C&S)	Mississinewa or lower
Rockford, E½ sec. 29, T. 27 N., R. 11 E.	Liston Creek (C&S)	Mississinewa or lower
White County:		
Monon, E½ 29, T. 28 N., R. 4 W. sec.	Huntington (C&S)	upper Niagaran

[1]C&S, Cumings and Shrock, 1928b; C, Cumings, 1930b.

[2] K&B, Kindle and Breger (not repeated in Cumings and Shrock), 1904.

AGE OF THE MISSISSINEWA SHALE AND THE LISTON CREEK LIMESTONE

We are convinced that the type relationship between the Mississinewa Shale and the Liston Creek Limestone is one of superposition by the Liston Creek, but, oddly enough, we are not so sure of the type relationship for any other pair of formations as they previously were understood. Thus we conveniently may treat the Mississinewa and the Liston Creek as a unit, speculate upon its age, and hang the remaining Niagaran strata from that determination. This unit has been placed low in the Niagaran, below other named formations, but now we must search through the fossils for reconciliation to a position at or near the top of the Niagaran, above other formations!

One limited newer study of Mississinewa and Liston Creek fossils was done by Robert H. Shaver in 1957. These fossils were collected during 1948-50 by William J. Wayne from interreef strata in the area shown on the Wabash and Lagro Quadrangles, where we deal with the type relationships of the two formations. The collection consists of about 24 named species, excluding the Bryozoa and graptolites, mostly from the Mississinewa. Although small, the collection has as many species as remain valid today for the Mississinewa near its area of typical exposures. (See table 1 for reassignment of some of the older so-called Mississinewa faunas.) The cephalopods and trilobites compare nicely with Lockport-Guelph species from New York, Ohio, Illinois, and Wisconsin, but they cannot be compared successfully with Clinton faunas, those of Flower (1942) and Foerste (1893), for example. Only in Indiana have beds commonly containing these species been correlated as low as Clinton and middle Niagaran. The trilobite *Dalmanites vigilans* is one example of a species whose range is not properly understood because of “guilt by association” and looser standards at an earlier date. It has been reported erroneously from the Waldron Shale of Indiana and the St. Clair Limestone of Arkansas, whereas Mississinewa specimens compare with type specimens from the Racine and Joliet Dolomites.

These conclusions are not really new; they can be reached also by analysis of the older lists, although newer taxonomic treatment would modify the names. Indeed, these conclusions have already been reached, at least implicitly, in the paleontologic literature. Kindle in Kindle and Breger (1904), Foerste (1931), and Cumings and Shrock, at one time, all reached similar conclusions in their faunal studies. Only as implicit in Kindles and Foerste's participation with Cumings in the Silurian Committee of the Geological Society of America can we find that they might have changed their minds. Without other knowledge, we may speculate upon what friction was generated in the committee among these stalwart, individualistic, and authoritarian gentleman geologists.

Cumings and Shrock's reliance on the Mississinewa and Rochester graptolites, along with the "Coral Beds," probably had more bearing than other factors on the Indiana Niagaran correlations from 1928 forward (Swartz and others, 1942; Esarey and Bieberman, 1948). We find that in 1928 "by far the most striking feature of the Mississinewa shale is the graptolite fauna .... The fauna (all groups except graptolites) so far seems to be more nearly transitional between the Rochester and Lockport, than characteristic of one or the other. It appears then that any final correlation must rest with the graptolites . . . . Since the graptolite fauna of the Mississinewa shale agrees almost exactly with the graptolite fauna at Hamilton, Ontario, the two must be equivalent .... That age would have to be early Lockport [but because of] the presence of several typical Rochester forms... we should be inclined to consider the upper Mississinewa shale of very late Rochester or early Lockport age." Yet by the percentage-of-common-Forms method the other groups of fossils are not transitional but favor the Lockport; by Cumings and Shrock's count only three species (graptolites) in the total fauna are restricted to the Rochester, but 15 species of graptolites and 6 species of other fossils are restricted to the Lockport! In the same report it was considered that the total Liston Creek fauna "fits in well with the typical Lockport fauna of New York and Ontario," and several difficult-to-explain Guelph species were noted.

The Mississinewa graptolite fauna consisted in 1928 of 28 species; 24 of these were found at Yorktown, 7 miles southwest of Muncie, in Delaware County. Only seven species were recorded from the Mississinewa in the Wabash-Lagro and type areas. The Yorktown graptolites came from rocks that we now consider to be low in the Mississinewa and below any type exposure, or possibly they are pre- Mississinewain age. Thus, persons with faith in Rochester and Yorktown graptolites may have some reason to correlate the rocks at Yorktown with the Rochester but not with the type Mississinewa, and the fossils tell a clearer story today than ever before.

In 1930 Cumings published new additions to the Mississinewa and Liston Creek species lists; these additions seemed to tip the scales in favor of pre-Lockport correlation. To justify this position for the cumulative total fauna, however, it is still necessary to resort to "new forms appear first in the reef facies" and to assume that this condition, nevertheless, has secondary importance. (See Esarey and Bieberman, 1948, p. 19.) Cumings (1941, p. 131) later concluded that the Mississinewa clearly is Rochester in age and that the Liston Creek is pre-Lockport. Our present stratigraphic evidence suggests that the 1930 Mississinewa-labeled collecting site near Peru, Miami County, is above the Mississinewa stratigraphically and that the Liston Creek site in the bioherm at Lapel (stop 6) is lower than the Liston Creek.

One of the most recent studies of Niagaran faunas in the United States has been done by Thomas Amsden of the Oklahoma Geological Survey. He (1949, p. 35-36) thought that previous correlations of the Liston Creek with the Louisville Limestone and the western Tennessee equivalent (Brownsport Formation) are based on too insufficient faunal evidence to warrant definite conclusions.

AGE OF THE ROCKS CALLED HUNTINGTON DOLOMITE

The Huntington Dolomite as earlier defined and mapped was thoroughly thought to be Lockport-Guelf (Racine, Guelf, and Cedarville) (fig. 5) in age as shown by a profuse fauna of more than 150 species. Now we suggest that the strata hosting the Huntington fauna very nearly span the Niagaran. Can the fossil evidence be reconciled? We do not question the assignment of Huntington rocks at Huntington and in the western area to a position high in the Niagaran. In fact, our interpretation of these rocks as facies of the Mississinewa and Liston Creek supports our assignment of these two interreef formations to a position high in the Niagaran, and we shall leave well enough alone. The eastern Huntington fauna of Randolph and Jay Counties does require an attempt at reconciliation, inasmuch as we now consider that the host rocks are low in the local Niagaran section.

Cumings and Shrock's correlation of the Huntington with the Racine and Guelph Dolomites took cognizance of the genera of corals and brachiopods of "distinct Guelphic affinities" and of the similarity of the mollusks to Racine and Guelph forms. When we itemize the species of those genera and add two Huntington trilobite species that were known outside of Indiana only from the Lockport, Racine, and Guelph, there are 24 Huntington species singled out because of their Racine and Guelph affinities. Of these, 14 species are found in the type area of the Huntington and at the Little Wabash River locality, and 14 are found in the western area of Huntington exposures; only 4 of the significant species are found in Jay and Randolph Counties of the eastern area, yet the Randolph County area provided a considerably larger total fauna than did the type area. Also interesting is the fact that all nine of the New Corydon species considered by Cumings (1930b, p. 206-207) as typical Guelph species, or as favoring the Guelph, came from the Little Wabash River site near Huntington. Not one came from the type area of the New Corydon Limestone in Adams and Jay Counties.

Busch (1939a and b) based the following stratigraphic identifications wholly or in part on faunal evidence: (1) his Huntington (restricted) as far south as Ridgeville, Randolph County, (2) the Cedarville Dolomite of Ohio underlying the Huntington (restricted) at Ridgeville, and (3) correlation of the Huntington (restricted) and New Corydon Limestone into Ohio. The Huntington (restricted) fauna consists of 194 species of which 17 "strongly indicate an early Guelph age." Eight of the seventeen occur collectively at five localities in Indiana, only one species at Ridgeville, and one to five species at each of the quarries at Bluffton, Markle, Lancaster, and Warren in Wells and Huntington Counties. One Guelph species from Ridgeville is more compatible with our assignment of greater age to the rocks at that location, but we would hardly be fair to use the somewhat greater number from the other localities as support for our assignment of late Niagaran age at those localities.

We should like to draw attention to the *Pentamerus oblongus* bed in the so-called Huntington rocks at Ridgeville, Randolph County (stop 8). Similar coquinas are found elsewhere in the southeastern area of Huntington exposure in Indiana, as at the Rockledge Products, Inc. quarry near Portland, Jay County, and at several other Indiana and Ohio localities. Guelph affinities of this species have been suggested at various times, but *Pentamerus oblongus* beds were noted by Bolton (1957, p. 41 and 44) to be characteristic of the middle Clinton rocks along the Niagara Escarpment in Ontario and by Foerste (1904, p. 35) as characteristic of the lowest Niagaran exposures nearest the Cincinnati Arch in Jay, Randolph, and Delaware Counties. Brachiopod coquinas in the Huntington rocks at Huntington and northwest of the conference area in Indiana consist especially of *Conchidium,* but *P. oblongus* also has been reported.

We have, in our prejudice, been selective of examples, and the fact remains that other authors were convinced that the rocks of Adams, Jay, and Randolph Counties are late Niagaran in age as shown by the fossils. The paleontologic evidence may not be conclusive. In fact, we appear to have left a great gap in the faunas, between the fossils of our lowermost Niagaran rocks in Randolph County and those of the Cedarville Dolomite (correlated both higher in the Niagaran and with the Randolph County exposures), at about the Ohio State line. We may have pleased at least the paleoecologists by admitting that the remaining anomalous faunal evidence is better left to their judgment.

GEOMORPHIC HISTORY

The area covered by this field trip lies within the northeastern part of the Tipton Till Plain (Malott, 1922). This geomorphic region is part of the Till Plain Section of the Central Lowlands Province of the United States as classified by Fenneman (1938). The topography is characteristically undulating till plain modified locally by end moraines that commonly rise so gradually above the till plain that they are not conspicuous and may be readily recognizable only by a person trained in glacial geology. Tills belonging to the Tazewell and Cary Substages of the Wisconsin glacial stage are present in the area. The Union City Moraine, which crosses the area about midway between Marion and Kokomo, is believed to mark the boundary between the two substages. In this part of Indiana topographic contrasts between the areas of Tazewell and Cary drift are not marked, but a greater clay content in the Cary till makes it possible to distinguish it from Tazewell till.

Probably the most interesting topographic features to be seen on the trip occur along the Wabash Valley. The present Wabash River is a considerably larger stream than its preglacial predecessor, and its increase in size has come about as a result of glacial modifications of drainage lines in Indiana. The Wabash River is superposed on glacial drift across buried preglacial uplands and lowlands with little control by preglacial topography upon its course. As a consequence the width and characteristics of the valley vary noticeably; this variation depends upon whether the valley is being cut in the bedrock of buried uplands or in the unindurated glacial materials filling preglacial lowlands. In the Rich Valley area, the Wabash Valley intersects the course of the buried Teays Valley (a major Tertiary river of east-central United States), and as a consequence of the greater susceptibility to erosion of the glacial materials filling the Teays Valley, the Wabash Valley widens pronouncedly at their point of intersection. East of Rich Valley, the Wabash Valley becomes notably narrow, because from here to near Huntington its valley is being cut in buried Silurian bedrock. Partial exhumation of the Silurian bedrock has revealed a large number of bioherms. These form bedrock mounds or hills known as "klintar" in the valley. One of the most conspicuous of the klintar is seen at stop 3.

The Wabash Valley served as a major Wisconsin sluiceway that carried great quantities of glacial outwash and melt water. The extensive gravel terraces that are seen at many places along the valley are remnants of the great volume of valley-train materials that were deposited down the valley.

For a short time during the Cary Substage the Wabash Valley received the overflow waters from Lake Maumee, which lay to the east of Fort Wayne, through the Fort Wayne spillway. This broad spillway joins the Wabash Valley at Huntington, and the route for the field conference follows it as far northeastward from Huntington as the village of Roanoke. It seems readily apparent that the Little Wabash River, which now occupies the lower part of the spillway, is an underfit stream far too small to have cut so broad a feature as the Fort Wayne spillway.

ITINERARY

SA'T'URDAY, MAY 6, 1961; STOPS 1 TO 5

Mileage between stops	
0. 0	Load vehicles at main (west) doorway of the Spencer Hotel, Marion, at 7:45 a. m. (CDT). Proceed straight ahead (north) to stoplight on northeast corner of square. (See fig. 10, the route map on the inside back cover.)
0. 1	TURN LEFT (west) on Third Street (State Route 18). Downtown Marion is on a narrow belt of outwash along the Mississinewa River, but route shortly crosses onto a ground moraine area of low relief. In Marion drift is of variable thickness. In the northern part of town, the Mississinewa Shale crops out along the river, but a short distance east drift more than 250 feet thick fills a buried tributary to the Teays Valley.
5.8	SLOW. Village of Sweetser. Drift in this area is less than 50 feet thick.
8.2	Cross Pipe Creek.
8. 3	TURN LEFT (south) onto blacktop road; cross railroads.
8. 5	TURN RIGHT (west) into quarry of the Pipe Creek Stone Co. Park as directed.
8. 7	STOP 1. PIPE CREEK STONE CO. QUARRY: Time allowed for this stop is 30 MIN UTES.

The quarry is in the NE¼SE¼- sec. 35, T. 25 N. , R. 6 E. , near Sweetser, Grant County. Normal lithologies of the Mississinewa Shale and the Liston Creek Limestone are seen here, although there is a bioherm near the southwest end of the quarry. The undulatory Mississinewa Liston Creek contact is exposed in an old pit, from which Mississinewa rock was extracted for the manufacture of rock wool. A minor flexure is visible in the north wall of the pit where for a distance of at least 400 feet from the crest beds dip slightly to the east and west.

The following section was measured by Arthur P. Pinsak and Jack A. Sunderman on July 13, 1960, in the northeast end of the old shale pit along the northwest facing wall. Exposures are most accessible along the ramp leading into the pit.

	Ft
Silurian System:	
Liston Creek Limestone, 20. 1 ft exposed:	
3. Limestone, cherty, light-gray to tan-gray; flaggy bedded and wavy bedded, fine grained to medium grained, fossil fragmental; some color banding due to concentration of pyrite and chlorite-glauconite melanterite; chert is milk white to dark gray, irregularly bedded, and nodular, with relict fossil structures and transitional boundaries; chert is absent from bottom 3. 5 ft; in some places surface of unit has strongly developed rhomboidal joint pattern (3 to 10 ft across) emphasized by solution below drift	17.0
2. Limestone, banded gray-green and gray-tan; fine grained to medium grained, fossil fragmental; color banding as above; irregular, texturally caused partings common; has small stylolites and vertical calcite veins; glauconitic, clayey, iron stained, and weathered in bottom few inches	3.1

	Ft
Silurian System--Continued:	
Mississinewa Shale, 10.0 ft exposed:	
1. Siltstone, argillaceous, dolomitic, gray, tan-gray, and gray-green; bedding indistinct or absent; has conchoidal to blocky fracture -	10. 0
3.0 ft covered to water level.	
Altitude at the base of the section is about 785 ft.	

Several rock cores that were cut just northwest of the southwest end of this quarry are on file at the Indiana Geological Survey. These cores show interesting lateral changes from the normal lithologies of the two exposed formations into a bioherm. The Liston Creek appears to thicken downward at the expense of the Mississinewa, but structure and differential erosion may be the cause. Toward the biohermal core the Liston Creek becomes dolomitic and lacks chert where its cored thickness reaches 33 feet. One core from near the center of the bioherm contains normal Mississinewa lithology below 73 feet of depth; the overlying rocks consist of fossiliferous dolomites and argillaceous limestones. Thus, the Mississinewa-Liston Creek contact, dipping toward the bioherm, may suggest sagging of the bioherm into the supporting substrata or differential settling of the flank rocks, but much of the biohermal interval that would be occupied normally by the Mississinewa Shale probably is a contemporaneous facies of that formation.

One of these cores (Appendix, section 2) penetrated Ordovician rocks whose top has been fixed at 308 feet below the ground surface and 250 feet below the top of the normal Mississinewa Shale.

Mileage between stops	
0.0	Return to vehicles.Retrace route to quarry entrance.
0.2	STOP. TURN LEFT (north) onto blacktop road and cross railroads.
0.4	TURN LEFT (west) onto State Route 18.
1.4	Cross railroad overpass, and TURN LEFT (south) onto State Route 13.
5.9	SLOW. Village of Swayzee.
8.2	STOP. TURN RIGHT (west) onto U. S. Route 35 and State Route 22.
10. 2	Enter Howard County. Route begins ascent of gentle back slope of the Union City Moraine.
15. 1	SLOW. Village of Greentown. Route descends dissected front slope of the Union City Moraine. The first basement test in Indiana was made during the years 1910-11 near Greentown (sec. 32, T. 24 N., R. 5 E.) by the Kokomo Gas and Fuel Co. Drilling revealed basement rocks at 3, 945 feet of depth, and the well was drilled to a depth of 3,996 feet. (See Kottlowski and Patton, 1953.)
16. 6	Cross Wildcat Creek. Enter area of ground moraine. Drift is here about 100 feet thick.
23.4	CAUTION. Continue STRAIGHT AHEAD across Kokomo bypass, U. S. Route 31, onto Markland Avenue. Drift beneath much of the city of Kokomo is less than 50 feet thick.
25.2	To the right (north) is the Markland Avenue Quarry, now owned by the Continental Steel Corp., type section of the Kokomo Limestone.

Markland Avenue Quarry Section

This section was measured by Cumings and Shrock (1928b, p. 125) in the quarry north of West Markland Avenue, Kokomo, Howard County, Ind., in the SE¼SW¼ sec. 36, T. 24 N., R. 3 E. The altitude at the top of the section is about 810 feet.

	Ft
6. Nodular, cherty limestone. Very badly weathered. Contains many fossils (Kenneth Limestone)	2-6
5. Red clay and chert and limestone pebbles	0.5
4. Much-broken, finely laminated limestone. The laminae stand at all angles. The cavities are filled with calcite. Crumpled bed. (Kokomo Limestone)	5-7
3. Finely laminated, light- to dark-colored limestone consisting of alternating layers of argillaceous and limy material. Dark toward base (Kokomo)	43.
2. Black argillaceous limestone containing petroleum. Weathers light gray (base of the Kokomo)	2.
1. Bluish-gray calcareous shale containing corals, brachiopods (*Atrypa reticularis* aa), and graptolites (Mississinewa Shale) (now believed to be Liston Creek Limestone)	7.

This quarry is now mostly water filled, and many of the old exposures have been covered by slag and other fill. The Kenneth Limestone, reported from the northeast corner of the quarry, can no longer be seen. A core taken from the northwest corner of the quarry is on display at conference headquarters, and a summary of the log of this core may be found on page 13 of this guidebook.

Mileage between stops	
25. 6	STOP. Just before bridge TURN LEFT (south) onto Park Avenue.
26.0	Cross Kokomo Creek. TURN RIGHT (west) on far side of bridge.
27.0	STOP. Cross road. Continue STRAIGHT AHEAD through underpass.
27. 3	TURN RIGHT (north) into quarry of the Yeoman Stone Co. Park as directed,
28. 0	STOP 2. YEOMAN STONE CO. QUARRY. Time allowed for this stop is 30 MINUTES.

The quarry is in the NE¼NE'¼ sec. 3, T. 23 N., R. 3 E., at the southwest edge of Kokomo, Howard County. The following section was measured by R. Dee Rarick and Robert H. Shaver, September 21, 1960, at the neck between the two wide portions of the inactive part of the quarry. Units 1 to 3 were described at the northeast corner of the neck, unit 4 at the northwest corner and west of the glacial channel, and the glacial units on either side of the neck. The thicknesses given for the Pleistocene units are maxima.

Pleistocene Series, about 40 ft exposed:	Ft
10. Soil, sand, and gravel, poorly exposed	5. 0
9. Gravel, cobbly and bouldery, lenticular	5. 0
8. Mudstone, sandy, conglomeratic, light-gray, calcareous; present only on south side of cut	8.0
7. Gravel, cobbles, and sand, obscurely to well stratified, locally crossbedded; upper part intertongues laterally with units 8 and 9	35.0
6, Mudstone, sandy, conglomeratic, light brown-gray, calcareous; thickens locally and lies on the Liston Creek Limestone	20.0

Pleistocene Series--Continued:	Ft
5. Gravel and rubble, very coarse, angular; composed mostly of slabs of Silurian limestones -	3.0
Silurian System:	
Kokomo Limestone, 26. 3 ft exposed:	
4. Limestone, dolomitic, conspicuously and thinly banded gray, brown, and tan, dense to fine-grained; banding is result of alternating layers having differing textures and compositions; rocks of this unit break into smooth slabs -	26.3
Liston Creek Limestone, 16.4 ft exposed:	
3. Limestone, cherty, gray and gray-tan, argillaceous, silty, dolomitic, fine-grained, fossiliferous; bedding cleavage spaced on medium to thick scale, but dark-gray indistinct thin contorted laminae are common; chert is in gray fossiliferous nodules and discontinuous beds several inches thick; vugs with petroliferous residue and calcite common; fossils include brachiopods and graptolites, especially *Dictyonema* - - - - - - - -- -	8.6
2. Limestone, gray and gray-tan, weathering mottled gray and rubbly, without chert; otherwise similar to unit 3 -- -	4.8
1. Limestone, similar to unit 3, especially with beds and nodules of gray splotchy chert and intimate mixtures of chert and limestone; exposed above water level -	3.0
Altitude of the base of unit 4 is estimated to be 740 ft above sea level.	

The rocks of unit 4 (Kokomo) belong to the "Waterlime" as described in earlier reports from several quarries in the city of Kokomo. Although the consensus from the older reports favors a Cayugan age for the Kokomo, the formation has been associated with the Devonian by some authors (Blatchley and Ashley, 1898; Miller, 1892), and John B. Patton (personal communication) presently prefers correlation with the middle part of the Jeffersonville Limestone. We here favor an age no later than Cayugan but invite comparison of these rocks with the thinly laminated rocks tentatively assigned to the Devonian System in the section measured for the May Stone and Sand, Inc. quarry (stop 4).

The contact between the Liston Creek and the Kokomo is fairly sharp and regular throughout much of the quarry; there is some transition through several inches from dirty-gray argillaceous limestone to brown dense conspicuously banded limestone. We doubt that this contact represents a major unconformity as some previous writers have suggested.

The lower rocks here (units 1 to 3) correspond to the lower rocks in the older Kokomo quarries that previously have been assigned to the Mississinewa Shale. The considerable content of carbonate and chert, however, and the room for a full Mississinewa section below prompt us to assign these rocks (units 1 to 3) to the Liston Creek.

Mileage between stops	
0.0	Return to vehicles and retrace route to quarry entrance.
0. 7	STOP. TURN LEFT (east) onto blacktop road.
1.0	STOP. Cross road. Continue STRAIGHT AHEAD.
1.8	BEAR LEFT at Y-junction.
2.0	BEAR LEFT (north) and cross bridge.
2.4	STOP. TURN RIGHT (east) onto Markland Avenue.

Mileage between stops	
4.5	CAUTION. Continue STRAIGHT AHEAD across bypass onto U. S. Route 35.
11. 4	Cross Wildcat Creek, enter village of Greentown, and ascend front of the Union City Moraine.
17.7	Enter Grant County. Reenter ground-moraine area.
19.8	STOP. TURN LEFT (north) on State Route 13.
21.3	SLOW. Village of Swayzee.
26.3	STOP. Junction with State Route 18 in village of Mier. BEAR RIGHT, cross overpass, and BEAR LEFT following State Route 13. Quarry of the Pipe Creek Stone Co. is just to the right (east).
32.0	Enter Wabash County.
33.6	Cross the Mississinewa River. In road cuts south of bridge, cherty thin-bedded Liston Creek Limestone is exposed. In gullies to the left (west) of road, 23 feet of this rock crops out and is underlain by 4 feet of noncherty thicker bedded cliff-forming limestone and 1 foot of tan dolomitic limestone which marks the base of the Liston Creek. Still lower and to the level of the river, 28 feet of Mississinewa Shale is exposed. Road cut north of the bridge shows thin-bedded cherty limestone steeply tilted on the south side of a bioherm, the core of which is not well exposed. Still another bioherm is ex posed in a creek about 1, 000 feet east of the bridge,
35. 6	Drift for past 20 miles has been approximately 50 feet thick. For the next 2 miles route crosses the northwestward-trending buried Teays Valley; drift thickness averages 300 feet. Buried valley has no surface expression in upland area but is shown as a conspicuous widening of the valley of the Wabash River where it crosses the Wabash Miami county line.
40.4	SLOW. Enter Wabash. TURN LEFT (west) onto Liberty Street beside school, where State Route 13 bears right.
40. 9	TURN LEFT (southwest) onto Pike Street.
44. 7	TURN RIGHT (northwest) just before bridge.
45. 6	TURN RIGHT into quarry of the Mill Creek Stone and Gravel Corp. Park as directed.
45. 9	STOP 3. MILL CREEK STONE AND GRAVEL CORP. QUARRY. Time allowed for this stop is 30 MINUTES.

The quarry is in the northeast corner of Reserve No. 11, T. 27 N. , R. 5 E. , 1 mile southeast of Rich Valley, Wabash County. This bioherm is one of a number of bioherms in the Rich Valley area. The so-called Rich Valley Reef, half a mile north of this stop, was a subject of the Third Indiana Geologic Field Conference (Esarey and Bieberman, 1949, p. 7) and was referred to as a “Liston Creek type of reef.” The same reef recently has been the subject of a sedimentary-petrologic study by A. V. Carozzi and J. B. Hunt (1960) of the University of Illinois.

The actual stratigraphic relationships between the Liston Creek Limestone and this bioherm cannot be observed, but some inferences can be drawn from the exposures between the crusher and quarry entrance. Characteristic fossil-fragmental cherty Liston Creek Limestone is hori-

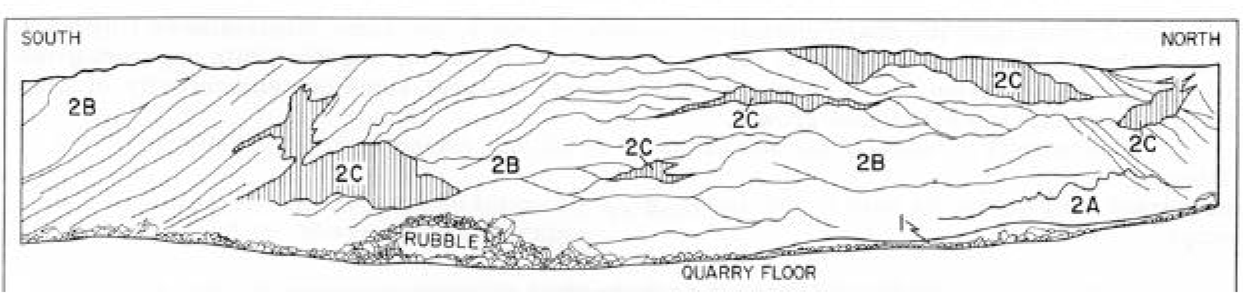


Figure 6. --Diagram of bioherm exposed in the quarry of the Mill Creek Stone and Gravel Corp. near Rich Valley, Wabash County (stop 3). Compiled from a composite photograph; horizontal width about 450 feet; height of face about 35 feet in the middle and slightly less at the ends. For description of numbered units see measured section.

zontally bedded at the crusher and in a small exposure in an old road cut about 100 feet to the northeast where the limestone is dolomitic as well as cherty. Steeply dipping beds of yellow-brown thin- to thick-bedded noncherty dolomite are exposed in gullies on the side of the hill 100 to 150 feet northeast of the old road cut. The cherty thin-bedded Liston Creek Limestone appears to grade into the steeply dipping beds of dolomite, but whether the rocks exposed at the quarry entrance are a reef facies of the Liston Creek Limestone or of the underlying Mississinewa Shale remains uncertain.

The following section was described by Robert H. Shaver and William J. Wayne on July 15, 1960, with mixed feelings of misgiving and relief, inasmuch as proof to our conferees of the complex relationships was being removed rapidly by quarrying operations.

	Ft
Silurian System:	
Biohermal facies, about 35 ft exposed:	
2. Limestone, dolomite, siltstone, and sandstone; bedded on flanks and constituting massive wedges in between. See figure 6: 2A, dolomite, gray, weathered yellow-brown, fine-grained; saccharoidal to coarsely fossil fragmental with dolomitized brachiopods, bryozoans, crinoids, corals, and stromatoporoids, recalling Huntington lithology; has dipping bedding surfaces continuous from 2B above; as much as 15 ft. 2B, limestone, gray to salmon-pink, dense to coarse-grained, fossil-fragmental; has irregular veins and vugs, some with calcite scalenohedrons as much as 5 in. long; medium bedded to thick bedded on flanks and comprising complex wedges in center; some limestone is dolomitic and tends to be buff and finer grained; about 35 ft exposed. 2C, penecontemporaneous? elastic wedges, beds, and patches (oversimplified in fig. 6); consisting of calcareous argillaceous siltstone and sandstone; arenaceous limestone and dolomite; argillaceous dolomite; various colors, some banding; bedding shaly to medium, some highly contorted; some lithology is characteristic of Mississinewa; some sandstone is calcareously cemented into large cleavable masses -	35. (approx.)
Mississinewa Shale, 6 ft exposed:	
1. Siltstone, blue-gray to yellow-brown, calcareous, argillaceous; bedding indistinct or absent; unit has characteristic coarse conchoidal fracture -	6.

The altitude of the quarry floor is about 660 ft above sea level.

Unit 2 rests upon the sharp undulatory surface of unit 1, and some Mississinewa lithology is seen higher in the face. The basal relationships of the bioherm, together with apparent gradation into normal Liston Creek lithology on the flanks, suggest some contemporaneity of Liston Creek deposition and biohermal growth.

Mileage between stops	
0.0	Return to vehicles and retrace route to plant entrance.
0.4	TURN LEFT (southeast) onto blacktop county road.
1.3	BEAR LEFT (northeast) on blacktop county road at Y-junction.
3.7	Half a mile north is the well-known and picturesque Shanty Falls, where a small stream tumbles over a 20-foot falls from the Mississinewa-Liston Creek contact and flows through a striking canyon to the Wabash River.
4.1	BEAR LEFT (northeast) at Y-junction. There are a great many limestone-constructed buildings from this point forward in the Wabash area. They include residences, schools and other public buildings, and business and industrial establishments. The “Wabash flaggings” also went into the locks and keepers' houses on the Wabash-Erie Canal. The stone came from a number of small hand-operated quarries that were opened in exposures of the Liston Creek Limestone along terraces in the valley between Wabash and Rich Valley, mostly on the north side of the river. The oldest quarries were opened more than 130 years ago, and the last operation was closed down about 12 years ago.
4.5	City of Wabash.
4.6	BEAR RIGHT (east) on Pike Street.
5.1	STOP. TURN LEFT (north) onto Vernon Street.
5.3	STOP. TURN RIGHT (east) onto Columbus Street.
5.9	STOP. TURN LEFT (north) onto State Routes 13 and 15 and Wabash Street. Rock ex posed in steep road cut to right (south) is the Mississinewa Shale with a few feet of the Liston Creek Limestone at the top.
6.0	Cross the Wabash River.
6.5	Intersection of Market and Wabash Streets. Probably the best known reef in Indiana is exposed about half a mile directly east of here and along the railroad tracks a few hundred feet north of the Big Four Railroad station in Wabash. It was a subject for the Third Indiana Geologic Field Conference (Esarey and Bieberman, 1949, p. 5) as well as for studies by Cumings and Shrock (1928b, p. 145-148).
6. 6	TURN LEFT (west) onto Hill Street.
7. 3	LUNCH STOP at the Wabash City Park on West Hill Street. Time allotted is 40 MIN UTES. An exposure of the Mississinewa Shale may be seen in the stream bank below pavilion.
0.0	Return to vehicles and retrace route to State Route 13.
0. 7	STOP. TURN LEFT (north) onto North Wabash Street and State Route 13.

Mileage
between
stops

1.1 TURN RIGHT (northeast) onto U. S. Route 24 and State Route 13 at junction.

3.4 BEAR RIGHT at junction following U. S. Route 24. A rise at this junction marks west edge of the Mississinewa Moraine.

4.9 A shallow streamless trough here, partly overlapped by an encroaching junkyard, was an outwash channel tributary to the Wabash sluiceway while glacial ice was building the Mississinewa Moraine. Throughout most of Wabash County the high-level (Mississinewa) terrace is carved on bedrock, but in a few places, as here in this slough, it is underlain by outwash sand and gravel.

6.1 The Mississinewa Shale crops out in road bank on the left and in other cuts for next few miles. Upstream in each of the small streams and unseen from the highway is a small waterfall at the Mississinewa-Liston Creek contact. The Liston Creek Limestone also caps the elongate valley braid core to the right just south of the railroad. The braid core is abutted on both ends by bioherms.

6.7 SLOW. Village of Lagro. Plant of the Celotex Corp. is on the right, and National Rock Wool Sales, Inc, is 0. 3 mile ahead. These companies and others at Wabash once used the Mississinewa Shale as a raw material in the manufacture of rock wool products. Exhaustion of the local supplies of natural gas and the present cost of fuel (coal and coke) have been instrumental in the companies[1] conversion from shale to slag from steel mills, which requires less energy to fuse.

7.1 Intersection with State Route 524 in Lagro. Lagro is on a low terrace in the broad troughlike valley now occupied below Huntington by the Wabash River and upstream from Huntington by the Little Wabash River. This valley, which our route follows for the next 22 miles, served as the outlet for glacial Lake Maumee, and the low terrace that stands 10 to 20 feet above the flood plain was carved when lake water flowed through the spillway at Fort Wayne. Many bioherms stand as klintar above the terraces.

8.6 The hill just south of the railroad is one of three klintar illustrated by Cumings and Shrock (1928b, p. 41 and 47) as having protected long tail slopes of shale or of glacial drift.

12.2 Enter Huntington County. Route here crosses two large coalescing bioherms.

13.4 Small bioherm well exposed on left.

14.3 The active gravel pit on the left exposes a thick section of gravel capped by clay-rich till that was deposited during the greatest advance of ice associated with the Mississinewa Moraine. Many similar gravel pits can be seen along the Wabash Valley, but most of them have been small operations that ceased when the overburden became too thick to handle economically.

14.6 Junction with State Route 105.

14.9 A large bioherm is exposed in the road cut and in the valley wall where the highway descends to the flood plain.

16.3 From here to Huntington highway remains at level of the Maumee Terrace. Note piles of large boulders on the terrace.

Mileage between stops	
20. 1	Memorial Park of Huntington on the left where an old quarry in a bioherm has been landscaped effectively into a sunken garden.
22.7	The Erie Stone Co. quarry on the right was a subject for the Third Indiana Geologic Field Conference (Esarey and Bieberman, 1949, p. 12). Exposures here are of com plexly interrelated rocks, both reef-core facies and bedded interreef facies, that have been assigned to the Huntington Dolomite and the Liston Creek Limestone. This quarry lies at the west end of the 3-mile-long type area of the Huntington Dolomite designated by Cumings and Shrock (1928b, p. 95). Cherty limestone, here considered to be the Liston Creek Limestone, crops out in the quarry and immediately to the east of the Huntington type area. The cherty limestone on the east, however, was identified as the New Corydon Limestone by Cumings and Shrock (p. 113), and it yielded most of the Guelph species of fossils that are attributed to that formation.
30.2	SLOW. Southeast edge of village of Roanoke.
30.4	TURN RIGHT (east) onto county road (Lower Huntington Road) at T-junction.
30.7	Cross Little Wabash River.
31.4	Enter area of the Wabash Moraine.
32.4	Enter Allen County.
32.6	BEAR LEFT (northeast) at Y-junction, following Lower Huntington Road.
37.6	Enter area of ground moraine.
38.6	Cross stream tributary to the Little Wabash River. For short distance road overlooks sluiceway valley of the Little Wabash River to our left.
41.3	TURN LEFT (north) onto Hayden Road at T-junction. Fort Wayne city limit. Enter sluiceway valley of the Little Wabash River.
42.1	TURN LEFT (west) into plant and quarry of May Stone and Sand, Inc. Park as directed.
42.5	STOP 4. MAY STONE AND SAND, INC. QUARRY. Time allowed for this stop is 1 HOUR.

The quarry is in the NW¼ sec. 29, T. 30 N. , R. 12 E. , at the southwest edge of Fort Wayne, Allen County. It has been operated in bedrock only since 1950, but it exposes one of the thickest manmade rock sections in Indiana. In addition to the 160 feet of Silurian and Devonian rocks, as much as 90 feet of glacial materials overlie the bedrock (fig. 7). PLEASE EXERCISE CAUTION AT THIS STOP.

Rocks in the Fort Wayne area were described by Cumings (1930a) from the cuttings of two 640-foot wells as consisting, below the glacial deposits, of 10 to 40 feet of Cayugan Greenfield Dolomite, 450 feet of Niagaran Huntington Dolomite, and 75 feet of Liston Creek Limestone. The Greenfield was thought to be equivalent to the Kokomo Limestone, and a marked similarity does exist between the thinly laminated rocks in the upper third of this quarry and the Kokomo in the Yeoman Stone Co. quarry (stop 2).

Fossil studies by A. C. Brookley in 1953 showed that the upper 12 feet of rock here (unit 12) probably is middle Devonian (Hamilton) in age, although Onondaga remained as a possibility. Arthur P. Pinsak suggests, from subsurface studies leading to this conference, that the thinly

Figure 7. --West and north walls of the quarry of May Stone and Sand, Inc. at Fort Wayne (stop 4).

laminated rocks (units 3 to 10) are lower-middle Devonian rocks that are correlatable with the Detroit River Group of the Michigan Basin. The lower two-thirds of the rock section occupy at least in part the stratigraphic position of the Mississinewa Shale. In addition, the Silurian rocks may occupy either part of the Liston Creek position or, more likely, part of the position of the unnamed Niagaran beds below the Mississinewa; thus the magnitude of the Silurian-Devonian unconformity is unknown.

The conspicuous section of Pleistocene deposits is near the west edge of the late Wisconsin Fort Wayne Moraine. These materials consist at one point, from bottom to top, of about 7 feet of sand and gravel, about 8 feet of clayey till, and about 35 feet of gravel. The lowest gravel probably is proglacial outwash that was overridden by ice; the second layer of gravel was laid down over the till after the ice receded to the northeast.

The following section was measured and described from the north walls of the quarry by Arthur P. Pinsak and Jack A. Sunderman, July 1960.

	Ft
Devonian System:	
Middle? Devonian rocks, 13. 5 ft exposed:	
12. Limestone, thin-bedded and flaggy, gray-tan, fine-grained, fossil -fragmental, fossiliferous; has many dark-colored partings in upper 2 ft; limestone surface below gravel is irregular	12.0
11. Dolomite, brecciated in sand matrix, gray and brown, fine grained; sand is fine and rounded and is in discrete sandstone lentils as well as matrix	0.5 to 1.5
Devonian or Silurian System:	
Lower-middle Devonian? rocks (Jeffersonville Limestone?), 34. 1 ft:	
10. Dolomite, sandy, light tan-gray, fine-grained, argillaceous; sand is in lentils and scattered grains	4. 5
9. Dolomite, thinly laminated, light-tan and brown; laminae are contorted; has calcite veinlets conformable to laminae	1.3 to 1.6
8. Dolomite, slightly sandy, mottled light- and dark-gray and tan, fine-grained; sand grains are very fine, rounded; has irregular shaly partings; unit has undulatory top and bottom surfaces	3.5
7. Dolomite, thinly laminated, brown, fine-grained	4.5
6. Dolomite, sandy, gray and tan, argillaceous; sand grains are fine, rounded; has irregular shaly partings; unit has undulatory top and bottom surfaces	0.8 to 1.1
5. Dolomite in five alternating units of thinly laminated and sandy rocks similar to units 6 and 7; some with undulatory contact surfaces	11.9
4. Dolomite, sandy, nodular, gray, fine-grained; sand grains are fine, rounded; unit has some green fissile shale	0.2 to 0.8
3. Dolomite, thinly laminated, brown, fine-grained	6.8
Pendleton Sandstone? , 0. 6 to 1. 2 ft:	
2. Dolomite, very sandy, gray, very fine-grained; sand grains are fine, well rounded; has dark-gray shaly partings; basal contact undulatory	0.6 to1.2
Silurian System:	
Biohermal facies in Mississinewa and possibly other stratigraphic positions, 109.0 ft exposed:	
1. Dolomite in interwedged biohermal lenses and biostromal units, with sandstone, especially along contacts of lenses; lenses as much as 20 ft thick; darker colored in upper 65 ft. Dolomite is variably blue gray, gray white, mottled, banded tan and gray, and stained blue green; mostly fine grained, also coarse grained, especially in vugs and recrystallized areas; has many molds and casts of fossils. Sandstone, associated with green clay, is in small lenses, white, calcareous, fine grained to medium grained; with rounded frosted grains. Exposed	109.0

The altitude of the top of unit 12 is about 720 ft.

Conferees may have an opportunity to second-guess part of our stratigraphy here, inasmuch as the quarry operator planned to deepen the quarry by 30 feet before conference time.

Mileage between stops	
0.0	Return to vehicles and retrace route to quarry entrance.
0.4	STOP. TURN RIGHT (south) onto Hayden Road.

Mileage between stops	
1.2	STOP. TURN LEFT (east) onto Lower Huntington Road at T-junction. Enter area of ground moraine.
1.6	STOP. TURN HARD RIGHT (south) onto Baer Avenue and State Route 3 at Y-junction.
6.4	Enter ground-moraine area of low relief.
9.4	Enter area of Wabash Moraine.
10.6	SLOW. Village of Zanesville. BEAR LEFT (south) onto State Route 303 at T-junction in town of Zanesville.
10.7	Enter Wells County.
13.0	Reenter area of ground moraine. Drift is less than 50 feet thick, here to atop 5.
17.1	SLOW. Cross the Erie Railroad tracks.
17.2	STOP. Continue STRAIGHT AHEAD on State Route 303 across U. S. Route 224.
18.4	STOP. Continue STRAIGHT AHEAD on State Route 303 across State Route 116.
19.0	Cross the Wabash River. There are very few terraces along the upper reaches of the Wabash.
22.0	TURN RIGHT (west) onto blacktop county road (100 N).
23.8	TURN RIGHT (north) into quarry of the Heller Stone Co. Park as directed. ,
24.2	STOP 5. HELLER STONE CO. QUARRY. Time allowed for this stop is 30 MINUTES.

The quarry is in the NE¼SW¼ sec. 29, T. 27 N., R. 11 E., at Rockford, miles northwest and northeast Wells County.

The Heller Stone Co. has cut a series of cores at points between 4 of this stop and a 93-foot core from the floor of this quarry. (See Heller Stone Co. Creviston no. 2 in Appendix.) All the deeper cores penetrated a 15- to 28-foot nodular ahaly dolomite at the expectable Waldron position. The top of this zone lies 55 feet below the quarry floor. At one of the northern points characteristic Mississinewa Shale was found to a depth of 40 feet in a hole that did not begin in reef or reef-detrital rocks and that was not drilled deeper. The projection of these data to this quarry suggests that the rocks here lie in the basal part of and below the stratigraphic position of the Mississinewa Shale. The exposed section is complicated by its position in and near biohermal structures.

The attitude and wedging of the beds, together with older reports on this quarry, which record a much greater stratigraphic thickness (measured normal tobedding) than now evident, suggest that the biohermal core lay to the southeast of the diagrammed section (fig. 8).

The following section was measured and described at the middle of the west wall of the quarry by Arthur P. Pinsak and Jack A. Sunderman, July 1960.

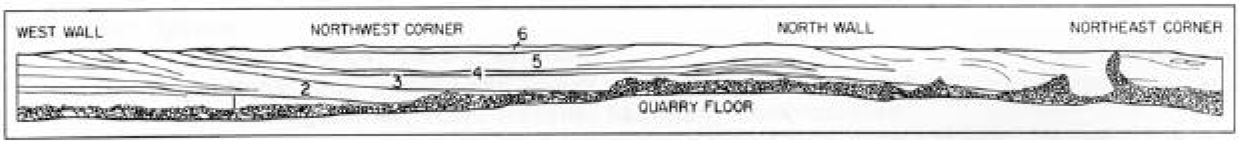


Figure 8. --Diagram of the walls in the northwestern part of the Heller Stone Co. quarry at Rockford, Wells County (stop 5). Compiled from a composite photograph; height of quarry face is about 30 feet. Some of the more conspicuous bedding surfaces are shown to indicate structural relationships in the flank of a bioherm, but they do not show magnitude of bedding. For description of numbered units see measured section.

Silurian System:	Ft
Mississinewa Shale (a reef-flank facies) and (or) lower Niagaran rocks, 29. 7 ft exposed:	
6. Dolomite, wavy and thin-bedded, gray to gray-tan, fine- to medium-grained, fossiliferous, vuggy with crystalline dolomite; has shaly and carbonaceous partings; weathers rubbly	3.1 to 4.2
5. Dolomite, thin-bedded, light-gray to tan-gray, fine- to medium-grained, fossil-fragmental, vuggy, fossiliferous; porosity is associated especially with many fossil molds and casts	7.5
4. Dolomite, cherty, tan, fine-grained, fossiliferous, vuggy; chert is dark gray brown to light gray porcellaneous with corroded boundaries; unit is bounded above and below by gray-green shaly partings; unit thickens northward to occupy much of the north quarry wall becoming very chesty and containing wavy argillaceous partings; weathers rubbly	1.5
3. Dolomite, thin- to medium-bedded, banded gray and dark-gray, fine-grained, argillaceous; has partings of calcareous shale	9.
2. Dolomite, chesty, mottled tan and gray, fire-grained, medium bedded, vuggy; chest is dark gray nodular, concentrated in bands	6.0
1. Dolomite, white to light-gray, glauconitic, fine-grained, pyritic; glauconite concentrated especially on bedding planes; upper surface is the quarry floor; exposed	1.0
The altitude of the quarry floor is 782 ft.	

Lenses of white sandstone occur at the top of the north face of the quarry. The sandstone is fine grained to medium grained and calcareous and consists of well-rounded and sorted grains. Maximum thickness of the sand lenses is 2 feet, and some of the top surfaces dip as much as 45° (S70°W). Similar sand lenses are associated with small biohermal and biostromal masses that may be seen near many Niagaran bioherms.

At the west end of the north wall pyritiferous high-alumina high-manganese shale beds occur within unit 4. The shale attains a maximum thickness of 3 feet, contains chest nodules and some ferric iron stain, and exhibits sulfur and calcium sulfate efflorescence on exposed surfaces. The bedding is highly contorted at this point and has high dips in all directions.

Mileage between stops	
0.0	Return to vehicles and retrace route to quarry entrance.
0.4	STOP. TURN LEFT (east) onto blacktop county road (100 N).
2. 1	STOP. TURN RIGHT (south) onto State Route 303.

Mileage between stops	
3.1	STOP. TURN RIGHT (west) onto State Route 124.
6.1	Enter Huntington County.
8.1	STOP. TURN LEFT (south) onto State Route 3.
11.7	Cross the New York, Chicago, and St. Louis Railroad.
13.2	Enter area of the Salamonie Moraine, a weakly developed end moraine formed during recession of the Erie lobe of the Wisconsin glacier.
14.4	SLOW. Continue STRAIGHT AHEAD on State Route 3 at junction with State Routes 5 and 118. Enter Wells County.
15.5	Cross the Salamonie River. Enter area of ground moraine.
17.4	State Route 3 passes over a sphagnum peat bog at this point. Through the years this highway has gradually subsided and has had to be rebuilt from time to time. An active peat moss operation can be observed east of the road.
20.3	Enter Blackford County.
21.3	SLOW. TURN RIGHT (west) onto State Route 18.
22.1	SLOW. Village of Roll (Dundee).
23.1	Enter area of the Mississinewa Moraine.
25.3	Enter Grant County. For about the next 5 miles route crosses main valley of the late Tertiary Teays River system. At this point drift thickens abruptly to about 400 feet.
35.3	SLOW. City of Marion.
35.7	TURN LEFT onto Branson Street and proceed 2 blocks.
35.8	TURN RIGHT onto Fifth Street, 1 block.
35.9	TURN RIGHT onto Adams Street.
36.0	STOP. Spencer Hotel, conference headquarters. End of trip for Saturday.

SUNDAY MORNING, MAY 7, 1961; STOPS 6 TO 8

Mileage between stops	
0.0	Load vehicles at main (west) doorway of the Spencer Hotel, Marion, at 7:45 a. m. (CDT). Proceed straight ahead (north) to stoplight on northeast corner of square.
C.1	TURN LEFT (west) on Third Street (State Route 18).

Mileage between stops	
1.1	TURN LEFT (south) onto State Route 37. Follow this route for the next 31 miles.
4.5	SLOW. BEAR RIGHT (southwest) following State Route 37.
7.0	SLOW. Junction with U. S. Route 35 and State Route 22. Continue STRAIGHT AHEAD on State Route 37. Route crosses a ground-moraine area of low relief.
14.8	To right (west) abandoned quarries expose a few feet of reef-core dolomite (recalling Huntington lithology).
15.5	SLOW. Village of Rigdon. Enter Madison County. Route crosses the low and indistinct Union City Moraine.
23.4	SLOW. City of Elwood to right (west). Continue STRAIGHT AHEAD on State Route 37.
25.9	Elwood Airport to left (east). The route to this point has been through an area in which the drift is generally 50 to 100 feet thick, but just south of the airport the drift is 300 feet thick in the narrow buried Anderson Valley. This valley has no present physiographic expression.
28.4	Route here follows western boundary of Madison County.
32.4	SLOW. TURN LEFT (south) on State Route 13 where State Route 37 bears right. Drift in this area is 50 to 100 feet thick. Route shortly descends onto the outwash-filled valley of White River, which at this point is about 2 miles wide.
33.8	SLOW. Village of Perkinsville. Cross the White River.
38.8	SLOW. TURN LEFT (east) into village of Fishersburg, following State Route 13.
39.1	STOP. Cross State Route 32 and continue STRAIGHT AHEAD on State Route 13.
39.2	Cross narrow outwash-filled valley of Stoney Creek, and TURN LEFT into quarry of the Standard Materials Corp. Park as directed.
39.6	STOP 6. STANDARD MATERIALS CORP. QUARRY. Time allowed for this stop is 35 MINUTES.

The quarry is in the NW¼NE¼ sec. 28, T. 19 N. , R. 6 E., at Lapel, Madison County. This large quarry was opened more than 30 years ago, and quarrying operations continue to enlarge the known vertical and lateral extent of a large bioherm. The center of the bioherm may still lie to the northwest of the exposure, inasmuch as nearly all exposed beds dip toward the southeast. Evidently a considerable part of the bioherm has been eroded.

Cumings and Shrock (1928b, p. 173), at a time when only the upper part of the section was exposed, assigned a Liston Creek age to the bioherm. The characteristic interreef flaggy cherty limestone of the Liston Creek is not seen here, although it is present 4 miles to the southwest and south. The nearest outcropping interreef strata, in a creekbed 1 mile west of the quarry at about 810 feet of altitude, have a lithology much like that of the Mississinewa Shale. The vertical thickness of rocks exposed along the east wall is approximately 80 feet, but a stratigraphic thickness, that is, one measured normal to the bedding, would present a tremendous thickness of section. Thus we believe that this bioherm has intertonguing relationships to the Mississinewa and perhaps older beds and that the present attitudes of the beds are mostly the result of primary structure.

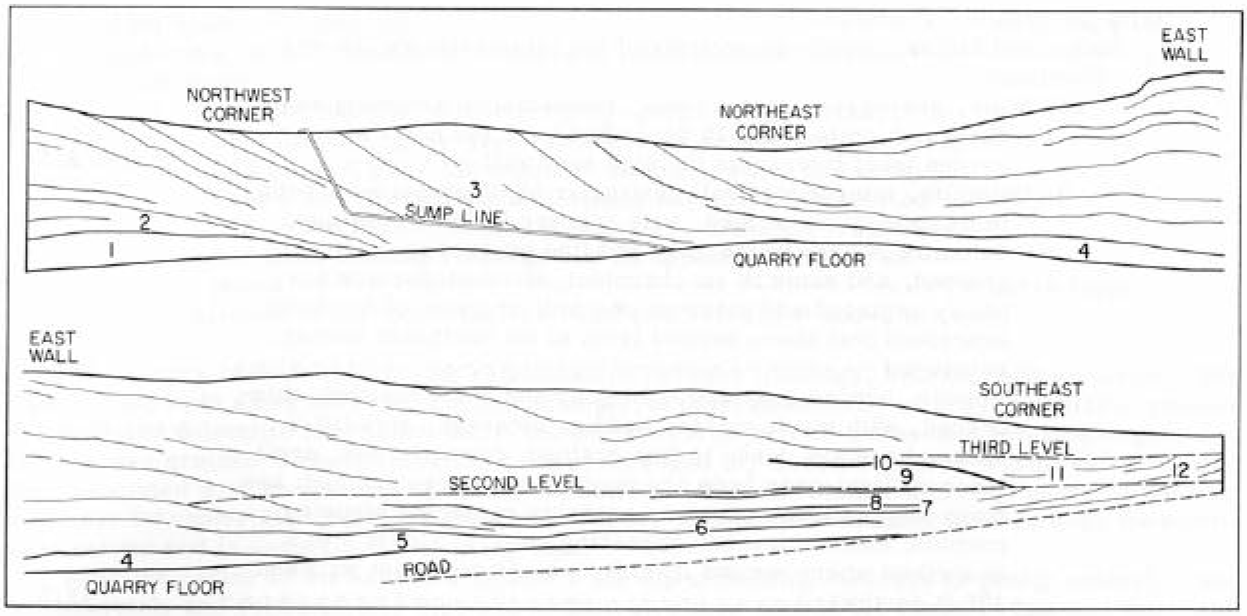


Figure 9. --Diagram of the walls in the Standard Materials Corp. quarry at Lapel, Madison County (stop 6). Compiled from a composite photograph; linear distance is about 1,800 feet, and height of the east wall is about 80 feet. Some of the more conspicuous bedding surfaces are shown to indicate wedging and attitude of beds in the flank of a bioherm, but they do not show magnitude of bedding. For description of numbered units and areas see measured section.

Refer to figure 9 when examining the following section that was described and compiled from several parts of the quarry by Robert H. Shaver and William J. Wayne, July 8, 1960.

Silurian System: Ft

Biohermal facies, mostly or entirely of the Mississinewa Shale:

12. Limestone and dolomite, medium to thickly bedded and interwedged, banded gray and tan, stylolitic with vertical columns at acute angle to bedding; beds dip strongly southeastward; dolomite is gray and fine grained, and some is porous and highly fossiliferous; limestone is light gray and tan and medium to coarse grained, in beds and wedges thickening updip as dip increases, and some limestone is dolomitic; some wedges are largely stromatoporoidal showing all stages of recrystallization; lenses of white friable sandstone are intercalated in this part of the section described generally for the southwest corner on the second quarry level; unit is partly equivalent stratigraphically to units described below - undetermined

11. Dolomite and limestone, interbedded and intermixed, banded and mottled gray, gray-green, and tan, thin- to medium-bedded, with coarser bedding cleavage; dolomite is gray and fine grained; limestone is light gray and tan and spongy looking to coarse grained, and some is largely stromatoporoidal; has many calcite-filled vugs developed in stromatoporoids which show all transitions to coarsely cleavable calcite; has shaly partings; described generally for the southeast corner on the second level -undetermined

	Ft
Silurian System--Continued:	
Biohermal facies, mostly or entirely of the Mississinewa Shale-Continued:	
10. Shale, gray-green, calcareous, thickening and dipping south eastward; units 9 and 10 described near the point where second level intersects the high east wall	0.5 to 2.5
9. Dolomite, interbedded with lenticular stromatoporoidal beds, thin- to medium-bedded, with coarser bedding cleavage; dolomite is gray to tan gray and fine grained to medium grained, and some is saccharoidal; stromatoporoids are partly replaced and make up one-half or more of the rock; described just above second level at its northeast corner; estimated	20.0
8. Dolomite, banded gray and light gray and some mottled, thin bedded, with much coarser bedding cleavage, stylolitic; darker beds are dense to fine grained, fossiliferous, argil laceous; light-gray beds are medium to coarse grained; has many vuggy calcite masses, probably replacing stromato-poroids; makes massive-appearing unit... ; units 5 to 8 described where second level intersects high east wall and 175 ft northward	12.5
7. Dolomite and dolomitic limestone, thinly interbedded, banded green-gray and light-gray, fossiliferous; dolomite is green gray, dense to fine grained, and argillaceous; limestone is light gray and medium grained; has calcite in veinlets and patches and probably replacing stromatoporoids; makes mas-sive-appearing unit	4.4
6. Similar to unit 7, with interbedding on medium scale; bedding cleavage on coarse scale; some calcite probably replacing stromatoporoids	6.7
5. Similar to unit 6; little or no calcite or stromatoporoids; where measured	11.1
4. Dolomite and dolomitic limestone, thinly to coarsely inter-bedded, banded gray-green and tan; dolomite is gray green, argillaceous, and dense to fine grained; limestone is tan, medium grained to coarse grained, and fossil fragmental; in beds as much as 6 in. thick; bedding cleavage planes widely spaced; exposed on east wall	9.0
3. Dolomite, strongly banded gray-tan and very dark-gray with some mottling; consisting of two principal dolomitic litholo-gies interbedded on medium to thick scale; one dolomite is gray tan and dense to fine grained but strongly fossil frag-mental in part with local abundance of dolomitized crinoid parts; porous in part; other dolomite is strongly crinoidal with dark-gray dense to fine-grained carbonaceous? matrix; unit has stylolites with vertical columns at acute angle to bedding; individual beds thicken updip; described generally for beds intersecting north wall above sump line	undetermined
2. Dolomite and limestone, interbedded on medium to coarse scale, banded gray-green and gray-tan with some dark gray; dolomite is gray green, argillaceous, and dense to fine grained; limestone is gray tan, coarse grained, fossil fragmental, and strongly crinoidal especially in dark-gray limestone; has some stylolites; individual beds thicken up-dip; described generally for beds in area indicated in the diagram	undetermined

	Ft
Silurian System--Continued:	
Biohermal facies, mostly or entirely of the Mississinewa Shale--Continued:	
1. Dolomite, banded to mottled gray-green and gray-tan, fossiliferous; gray-green dolomite is dense, argillaceous, and porous; gray-tan dolomite is fine grained and conspicuously and finely porous; porosity especially associated with dolomitized fossils, particularly crinoidal fragments; has little bedding cleavage and so appears massive; exposed	16.0 (approx.)
Altitude of the top of the east wall is about 830 ft above sea level.	

This quarry reveals interesting relationships between lithology, bedding, and structure. The flatter lying beds along the east wall, for example, consist dominantly of graybanded fine-grained dolomite and dolomitic limestone, but in the southwestern part on the second level light-gray and tan coarser grained stromatoporoidal beds are wedged in, become thicker northwestward, and are associated with steepening dip in that direction. The mid-height and high parts of the east wall near its center also suggest biohermal wedges. Conspicuous wedging is noted near the northwest corner and is associated with steep dips.

Near the center of the exposure of unit 1 the dip of bedding cleavage is gently easterly, and northeasterly and southeasterly dips are evident on either side of the center. Some of the rocks exposed on the vertical west wall above unit 1 are accessible just north of the ramp. Most of these rocks are iron stained, strongly fossil fragmental, and especially crinoidal and appear similar to the rocks of unit 3. Dips steepen upward along the west wall. From the structural evidence, then, the centralmost part of the bioherm has not yet been opened.

Mileage between stops	
0.0	Return to vehicles and retrace route to quarry entrance.
0.4	STOP. TURN LEFT (southeast) onto State Route 132, and follow through village of Lapel.
1.3	Continue STRAIGHT AHEAD where State Route 13 turns right.
1.5	BEAR LEFT (east) on blacktop road. Route crosses a ground-moraine area.
8.1	STOP. Continue STRAIGHT AHEAD across State Route 9. Route here crosses the upper end of abandoned melt-water channel that is now largely filled with lacustrine deposits. For next several miles our route crosses a series of narrow buried channels and tributaries of Anderson Valley; drift ranges from less than 50 to more than 250 feet in thickness.
8.5	STOP. Continue STRAIGHT AHEAD onto State Route 67. Follow this route for the next 18 miles.
8.9	Gravel pit to right (south) is in north end of the Anderson Esker.
12.3	TURN LEFT (north) following State Route 67.
13.6	BEAR RIGHT (east) following State Route 67.
16.4	Village of Chesterfield. Route crosses the upper end of an abandoned channel that formerly carried glacial melt water southward.

Mileage between stops	
17.7	Enter Delaware County. Ground-moraine area.
24.0	BEAR LEFT (north). Drift here is about 100 feet thick.
26.8	SLOW. TURN LEFT (north) onto blacktop road where State Route 67 bears right. Drift here is less than 50 feet thick.
29.0	TURN HARD LEFT (west) onto blacktop road just before bridge.
29.2	TURN RIGHT (north) into the Muncie Stone and Lime Co. quarry. Park as directed.
29.4	STOP 7. MUNCIE STONE AND LIME CO. QUARRY. Time allowed for this stop is 35 MINUTES.

The quarry is in the SW¼NE¼ - sec. 20, T. 20 N., R. 10 E., at the southwest edge of Muncie, Delaware County. This exposure is an important one in our exhibit, because it presents normal (interreef) lithologies of the upper part of the "unexposed" and "unnamed" Niagaran beds, and thus it contrasts with the bioherm-influenced rocks at approximately the same stratigraphic position in the Heller Stone Co. quarry (stop 5). Of course, these rocks have been observed for many years and have been called Liston Creek, but we now have the first opportunity for study in the newer stratigraphic light that shows these rocks are below the Mississinewa Shale.

The four upper units in the following section, measured by Arthur P. Pinsak and Jack A. Sunderman, July 15, 1960, were described from the south walls of the quarry; the lower three units were described from the sump in the northwest corner.

	Ft
Silurian System:	
Lower Niagaran rocks, 76. 7 ft exposed:	
7. Dolomite with wavy carbonaceous partings, gray and tan with some dark mottling, fine-grained, sporadically cherty; upper part more weathered and vuggy; weathers hackly to knobby because of the irregular partings; units 6 and 7 vary in thickness and complement each other; units 2 to 7 may occupy the stratigraphic position of the Louisville Limestone; exposed	28.0
6. Dolomite, similar to unit 7 but especially cherty, although chert content is less in upper part of unit and varies laterally; chert is dark gray and porcellaneous and is in nodules and bands; some chert has corroded boundaries and relict fossil structures; unit appears thick bedded but carbonaceous partings control knobby weathered surfaces	18.5
5. Dolomite, gray and tan to some dark-gray mottling, dense to medium-grained, fossil-fragmental, medium-bedded; has some thin irregular carbonaceous laminae and some dark brown chert; Fracture surfaces smooth to conchoidal	3.5
4. Dolomite, mottled tan and gray-tan, fine-grained, fossiliferous (molds and casts), locally porous and vuggy; bedding is indistinct, but unit has hackly to knobby fracture	7.0
3. Dolomite with wavy carbonaceous partings, gray-tan, fine-grained, thin- to medium-bedded, cherty near top; locally vuggy; has hackly to conchoidal fracture; chert is gray brown to white and porcellaneous	12.0
2. Dolomite, banded and mottled tan and light- to dark-gray, fine-grained, vuggy; has blocky fracture; pyritic along fractures; banding and mottling due to siliceous (tan) and argillaceous (dark-gray) intercalations	4.7

Silurian System--Continued:	Ft
Lower Niagaran rocks--Continued:	
1. Dolomite, dark-gray, argillaceous, thin-bedded, dense to fine-grained; grades laterally to calcareous shale; pyritic along fractures; unit may occupy in part the stratigraphic position of the Waldron Shale; exposed thickness- -	1.0
Covered to water level -	2.0

The altitude of the quarry floor at the base of unit 4 is 877 ft above sea level. The average dip of the beds in the main part of the quarry is about 12° S. , and dips of 2½° S. are present in the sump.

Mileage between stops	
0.0	Return to vehicles and retrace route to quarry entrance.
0.2	TURN LEFT (east) onto blacktop road.
0.4	TURN LEFT (north) onto Hoyt Avenue and cross bridge over Buck Creek.
1.8	TURN RIGHT (east) onto Willard Street at stoplight.
2.3	STOP. TURN LEFT (north) onto Madison Street, State Route 67, at stoplight. Follow this highway for the next 12 miles.
3.1	TURN RIGHT (east) following State Route 67.
3.3	Cross the White River, which here marks the frontal edge of drift associated with the Union City Moraine, here indistinguishable topographically.
3.5	SLOW. TURN LEFT (north) following State Route 67.
5.5	Continue STRAIGHT AHEAD on State Route 67 where State Route 3 turns left. The drift here is less than 50 feet thick. The low hills that rise from an otherwise feature less ground moraine on both sides of the highway for the next several miles are com posed of ice-contact stratified drift and probably were formed during recession of ice from the stand that built the Union City Moraine. They are part of the Muncie Esker.
10.6	Cross the Mississinewa River. Hills are part of the Muncie Esker.
12.0	Reenter ground-moraine area.
14.5	SLOW. Village of Albany. Continue STRAIGHT AHEAD (east) onto State Route 28 where State Route 67 turns left.
15.8	Leave village of Albany. Outcrops of cherty limestone and dolomite in this vicinity generally were called Liston Creek Limestone in earlier reports.
16.2	Enter Randolph County. Drift in this area is less than 50 feet thick. Route generally follows outer (south) margin of the Mississinewa Moraine.
17.4	SLOW. Village of Fairview.
20.0	SLOW. Continue STRAIGHT AHEAD across State Route 1.

Mileage between stops	
21.0	Route for next 2 miles crosses a large northward-trending tributary to the Teays Valley. Drift is 250 feet thick, and the buried valley has no surface expression.
26.1	SLOW. Enter village of Ridgeville. Drift in this area is less than 50 feet thick.
26.5	STOP. Center of Ridgeville. TURN RIGHT (south) following State Route 28.
27.0	Cross the Mississinewa River and BEAR LEFT (east) following State Route 28.
27.7	TURN LEFT (north) into quarry of the H and R Stone Co. Park as directed.
28.1	STOP 8. H AND R STONE CO. QUARRY. Final stop of conference.

The quarry is in the NE¼SE¼ and in the SE¼SE¼ sec. 12, T. 21 N., R. 13 E., southeast of Ridgeville, Randolph County.

Corresponding rocks in an abandoned quarry less than half a mile distant were described as Huntington Dolomite by Cumings and Shrock (1928b, p. 95). Patton (1949, p. 13), however, citing a communication from D. F. Bieberman concerning the absence of the Misaiasinewa Shale from well cuttings from this area, suggested that these Huntington rocks might underlie the Missisainewa Shale. Recent studies leading to this conference have shown this suggestion to be the case. These rocks, although called Huntington, also are part of a sequence of lower Niagaran dolomites (here equivalent of the Laurel Limestone and possibly the Osgood Formation) which atratigraphically lie below the Mississinewa Shale and above the Brassfield Limestone and Ordovician rocks.

The following section was measured and described in the northwest corner of the quarry by Arthur P. Pinsak and Jack A. Sunderman, July 15, 1960.

	Ft
Silurian System:	
Lower Niagaran rocks, 48.4 ft exposed:	
4. Dolomite, gray and cream, thin-bedded, fine- to medium-grained, porous, locally fossiliferous; fossils include corals and low spired gastropods; unit appears to be an altered (dolomitized) fossil-fragmental oolitic limestone; units 1 to 4 occupy in part the stratigraphic position of the Laurel Limestone and possibly the Osgood Formation; exposed thickness	6.0
3. Dolomite, fossiliferous, tan-gray, and iron-stained; fine grained and vuggy; fossils consist of molds and caste especially of *Pentamerua oblongua;* has few stylolites and is bounded above and below by stylolites	0.9
2. Dolomite, cherty, tan and gray with some lighter colored siliceous bands; fine grained to medium grained, porous, vuggy, and fossiliferous; chert is dark gray to white and porcellaneoua with al tered rims; gross aspect massive, but thin bedded to medium bedded with stylolites and indistinct bedding planes; basal 4 ft transitional (siliceous; noncherty)	20.0
1. Dolomite, irregularly banded and mottled cream, light-gray, and dark-gray; indistinctly to irregularly medium bedded, medium grained, porous, vuggy, and fossiliferous; top of unit makes the first ledge of quarry; exposed thickness	21.5
Altitude of the quarry floor at the base of unit 1 is about 905 ft.	

Unit 4 of the described section, with its oolitic aspect, may correspond to the 5-foot pseudooolitic unit described by Cumings and Shrock (1928b, p. 108) in the abandoned quarry at Ridgeville. This texture, together with the brachiopod fossils, was thought to be significant in correlating the Huntington between northwestern Indiana and Ohio.

Busch (1939a and b) relegated the lower 43 feet of the 70-foot section in the abandoned quarry to the Cedarville Dolomite. Thus, in this active quarry the rocks of unit 1 and part of unit 2 probably would be called Cedarville by Busch, and his restricted Huntington would include the rocks of part of unit 2 and units 3 and 4. (See the discussion under "Huntington Dolomite.")

We invite your close attention to these rocks, particularly units 3 and 4, because it is from these and similar rocks that a Guelph fauna has been recognized. If a Guelph fauna does exist here, we have the most serious objection to the ideas presented in this guidebook; certainly our suggestions for interregional correlation hang in the balance, if not our suggestion for order of local stratigraphic sequence.

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APPENDIX

Section 1. Log of core from Heller Stone Co. Creviston no. 2, near Markle, Huntington County, Ind. (SE¼SE¼ sec. 11, T. 27 N. , R. 10 E.). Altitude, 788 ft. Log by Robert H. Shaver, December 9, 1960.

	Depth (ft)
Silurian System:	
Biohermal rocks in Mississinewa stratigraphic position, 32.5 ft cored:	
1. Dolomite, very porous, vuggy, light-tan and tan-gray, iron stained in part, fine-grained, saccharoidal to coarse grained, fossil-fragmental in part; has much porosity associated with dolomitized coquinas especially of corals *(Favosites)* and brachiopods; has a few stylolitic partings	5.0-37.5
Noncharacteristic Mississinewa facies? , 31 ft:	
2. Dolomite, gray-tan, fine-grained, medium-bedded with many irregular shaly carbonaceous partings and thin irregular siliceous? laminae; has few vugs and slight porosity	37.5-68.5
Lower Niagaran rocks, 135.5 ft cored:	
3. Dolomite, faintly mottled light shades of gray, tan, and yellow-tan, fine-grained, saccharoidal; has many small pores and vugs; has few stylolitic partings	68.5-123.8
4. Dolomite, nodular, argillaceous, dark-gray, dense; has many wavy black carbonaceous partings wrapped around nodular components; unit is in Waldron stratigraphic position	123.8-141.0
5. Dolomite, gray with some tan mottling, fine-grained, saccharoidal in part; has much porosity associated with vugs and dolomitized fossils, especially crinoid fragments	141.0-148.5
6. Dolomite, oolitic, light-tan, fine-grained, saccharoidal in part; has many fine pores and few stylolitic partings	148.5-159.5
7. Dolomite, very porous, vuggy, light shades of gray, tan, and yellow tan, fine-grained, saccharoidal to coarse-grained; porosity associated with many dolomitized fossils, especially crinoid fragments; unit is similar to unit 1; units 1 and 5 to 7 are characteristic of Huntington lithology but occupy in part the stratigraphic position of the Laurel Limestone	159.5-204.0

Section 2. Log of core from Indiana Geological Survey drill hole no. 25, near Sweetser, Grant County, Ind. (NW¼-NW¼ sec. 2, T. 24 N., R. 6 E.). Altitude, 814 ft. Modified from logs by Robert H. Shaver and Jack A. Sunderman, July 1960.

	Depth (ft)
Silurian System:	
Biohermal rocks, 47. 6 ft cored:	
1. Dolomite, very porous, vuggy, yellow-brown, iron-stained, and gray; fine grained and saccharoidal in part; oolitic? locally; porosity is associated with many dolomitized crinoids, brachiopods, and corals; unit is gray, medium grained, and fossil fragmental in lower few feet; unit occupies in part the stratigraphic positions of the Liston Creek Limestone and the Mississinewa Shale exposed in nearby quarry	11.4-59.0
Mississinewa Shale, 97.6 ft (minimum):	
2. Dolomite, argillaceous, dense, gray; strongly mottled gray and tan 101. 8 to 111. 5; bedding absent or indistinct	59.0-156.6

	Depth (ft)
Silurian System--Continued:	
Mississinewa Shale or lower Niagaran rocks, 12.4 ft:	
3. Dolomite, gray and gray-tan, fine-grained, saccharoidalin part, slightly porous; has few stylolites and irregular carbonaceous partings	156.6-169.0
Lower Niagaran rocks, 130. 7 ft (minimum):	
4. Dolomite, mottled gray, brown, and tan, dense to fine-grained, saccharoidal in part; has wavy black carbonaceous partings becoming more common downward	169.0-189.2
5. Dolomite, mottled tan and gray-tan, nodular, dense to fine-grained; has many wavy black carbonaceous partings wrapped around nodular components; Waldron stratigraphic position occupied wholly or in part by units 5 to 7	189.2-201.7
6. Dolomite, gray-tan and mottled tan and gray, dense to medium-grained; has porosity associated with dolomitized fossils especially crinoidal fragments; has few planar to irregular carbonaceous partings	201.7-215.7
7. Dolomite, nodular, argillaceous, dark-gray, dense; has many wavy black carbonaceous partings wrapped around nodular components, becoming planar partings below 226.8 ft	215.7-231.1
8. Dolomite, gray and tan, mostly fine-grained and finely porous; has medium-grained intervals; has dolomitized or silicified crinoid fragments; has green-gray shaly partings in lower few feet	231.1-299.7
Brassfield Limestone? , 8.6 ft:	
9. Dolomite, brown, medium-grained, porous, stylolitic; becomes fine grained, saccharoidal downward; insoluble residues reveal mixed Ordovician and Silurian conodonts in lower few feet	299.7-308.3
Ordovician System:	
Cincinnatian rocks, 15.2 ft cored:	
10. Shale, gray-green; has Cincinnatian macrofossils; has pods of gray fine-grained dolomite and fossil fragments	309.0-310.7
11. Shale as above interbedded with gray-tan granular dolomite resembling that of unit 9	310.7-313.4
12. Shale, dark-gray and gray-brown and gray-green with thin laminae of gray fine-grained dolomite; has dolomitized fossils	313.4-322.2
13. Dolomite, gray and mottled gray-green; appears coarse grained but consists of mixtures of dark granular dolomite and light-colored dense dolomite	322.2-324.2

Section 3. Log of core from Indiana Geological Survey drill hole no. 44, Rockledge Products, Inc. quarry, Jay County, Ind. (NW¼NW¼ sec. 30, T. 23 N., R. 14 E.). Altitude, 835 ft. Modified from log by Robert H. Shaver, July 1960.

	Depth (ft)
Silurian System:	
Lower Niagaran rocks, about 68.0 ft cored:	
1. Dolomite, tan, fine-grained, saccharoidal to coarse-grained, glauconitic; has vuggy porosity; bedding indistinct or absent; slightly cherty, 30 to 35 ft	10.6-40.0
2. Dolomite, light to medium blue-gray, fine-grained, saccharoidal to medium-grained; has vuggy porosity and clayey to stylolitic partings; crinoid stems abundant in upper part; units 1 and 2 occupy in part the stratigraphic position of the Laurel Limestone and Osgood Formation	40.0-78.1

	Depth (ft)
Silurian System--Continued;	
Brassfield Limestone? , about 24 ft:	
3. Dolomite, similar to unit 2 but is glauconitic and has light colored chert nodules down to 91.1 ft- -	79.2-92.6
Silurian and Ordovician Systems:	
Brassfield Limestone? and Cincinnatian rocks:	
4. Dolomite, gray, grading down to brassy brown in bottom 6.5 ft, fine- to medium-grained; has thin laminae and fragments of gray-green shale; has vuggy porosity; Ordovician top picked at 100 to 105 ft on conodonts from in soluble residues -	92.6-116.3
Ordovician System:	
Cincinnatian rocks, about 130.0 ft cored:	
5, Shale, dolomitic, gray-green; has pods and irregular laminae of gray medium-grained dolomite probably replacing bryozoans and other fossils- -	117.0-120.3
6. Limestone, dolomitic, medium-grained, brassy-brown as the rocks are at 109.8 to 116.3 ft- -	120.3-126.4
7. Shale, dolomitic, gray to gray-green; has intervals as much as 0.8 ft of gray medium-grained dolomite and many pods of dolomite replacing fossils- -	126.4-144.8
8. Limestone and dolomite, thickly interbedded, tan, gray, and gray-green, dense, argillaceous to coarse-grained -	144.8-172.3
9. Limestone, shale, and dolomite, thickly interbedded; has highest recognizable Ordovician macrofossils -	172.3-232.7

Section 4. Log of core from Indiana Geological Survey drill hole no. 41, near Groomsville, Tipton County, Ind. (NW¼NE¼SE¼ sec. 17, T. 22 N., R. 3 E.). Altitude, 874 ft. Modified from logs by Arthur P. Pinsak and Robert H. Shaver, October 1960.

	Depth (ft)
Devonian System:	
Pendleton Sandstone, 3 ft cored:	
1. Sandstone, fine-grained, in gray-green argillaceous carbonate matrix; sand grains are clear, well sorted, and rounded- -	140.0-143.0
Silurian System:	
Liston Creek Limestone? , 103.2 ft:	
2. Limestone, fossiliferous, light-tan, fine- to coarse-grained, fossil-fragmental, in fine-grained dolomitic matrix; has few petroliferous and calcite-filled vugs and stylolites; fossils consist especially of brachiopods- -	143.0-152.1
Core loss, 152. 1 to 169.0.	
3.Dolomite, gray, dense to fine-grained, saccharoidal -	169.0-170.0
Core loss, 170.0 to 182.8.	
4. Limestone, variably gray, salmon-pink, and tan, mostly coarse-grained, fossil-fragmental in gray and tan dense matrix of dolomitic limestone; has patches of coarsely cleavable clear calcite and few irregular green shaly partings -	182.8-246.2
Mississinewa Shale, 109.8 ft:	
5. Limestone, dolomitic, argillaceous, cherty, gray, dense, with some coarse-grained fossil-fragmental beds; has crinoid stems; chert is in small gray and white (corroded) fossiliferous nodules; has many thin indistinct irregular argillaceous laminae; possibly this unit should be assigned to the Liston Creek -	246.2-268.2

	Depth (ft)
Silurian System--Continued:	
Mississinewa Shale--Continued:	
6. Dolomite, argillaceous, gray, dense; has many tiny silicified fossil fragments near top; has a few gray-pink medium grained limestone intercalations throughout and especially at the bottom	268.2-356.0
Lower Niagaran rocks, 127.0 ft:	
7. Limestone, sublithographic; light tan above becoming strongly mottled dark gray and tan below; has irregular clayey partings; unit occupies stratigraphic position of the Louisville Limestone	356.0-395.3
8. Limestone, nodular, dark-gray, dense; has many wavy black carbonaceous shaly partings wrapped around nodular components; unit occupies stratigraphic position of the Waldron Shale	395.3-405.6
9. Limestone, dolomitic, gray to gray-pink, medium-grained, fossil-fragmental, in fine-grained dolomitic matrix; has stylolitic partings; units 9 and 10 occupy stratigraphic position of the Laurel Limestone and Osgood Formation	405.6-476.6
10. Limestone, dolomitic, with thin green shaly laminae and irregular intercalations; gray tan, medium grained, fossil fragmental, and glauconitic	476.6-483.0
Brassfield Limestone:	
11. Limestone, dolomitic, cherty, tan, dense to coarse-grained; chert is in gray-tan beds and nodules showing corrosion and relict fossil structures	483.0-523.8
Brassfield Limestone? , 11.4 ft:	
12. Limestone, dolomitic, tan grading down to dark gray, medium-grained; has clayey partings; insoluble residues reveal mixed Ordovician and Silurian conodont faunas in bottom few feet	523.8-535.2
Ordovician System:	
Cincinnatian rocks, 19.4 ft cored:	
13. Shale, dolomitic, or dolomite, argillaceous, gray and gray-green, dense to fine-grained; has characteristic Cincinnatian macrofossils in basal 2 ft	535.2-542.9
14. Limestone and shale; limestone is tan, medium grained to coarse grained, and fossil fragmental and has irregular intercalations of green fossiliferous shale; shale also in beds	542.9-548.8
15. Dolomite, argillaceous, gray-green, dense; has gray irregular pods of crystalline dolomite probably replacing fossils	548.8-554.6

Section 5. Log of core from Irving Bros. Gravel Co. , Inc. drill hole, near Desoto, Delaware County, Ind. (SE¼NW¼ sec. 25, T. 21 N., R. 11 E.). Altitude, 932 ft. Log by Robert H. Shaver, December 9, 1960.

	Depth (ft)
Silurian System:	
Lower Niagaran rocks, 140 ft cored:	
1. Dolomite, tan and mottled tan and yellow-tan, cherty, fine-grained, saccharoidalin part, moderately vuggy and porous; has few carbonaceous partings and irregular fine sandy intercalations; has thin white siliceous laminae in upper part and sparse white (corroded) chert nodules below 44.7 ft	26.0-57.8

Silurian System--Continued:	Depth
Lower Niagaran rocks--Continued:	(ft)
2. Dolomite, nodular, argillaceous, dense, dark-gray; has many wavy black carbonaceous shaly partings wrapped around nodular components; units 2 to 4 occupy stratigraphic position of the Waldron Shale, wholly or in part	57.8- 67.0
3. Dolomite, faintly mottled tan and yellow-tan, dense to fine grained, moderately and finely porous; has few clayey partings	67.0-89.8
4. Dolomite, argillaceous, dense, dark-gray; similar to unit 2 but in regular thin beds separated by thin planar dark-gray carbonaceous laminae; has dark-colored oolites in bottom lft	89.8-95.3
5. Dolomite, cherty; tan above 97. 3, mottled tan and gray above 108.0, and yellow tan below; dense to fine grained, moderately and finely porous; chert is in sparse white (corroded) nodules; has few clayey and stylolitic partings; similar to units 1 and 3	95.3-113.8
6. Dolomite, very porous, vuggy, light-gray and yellow-tan, fine-grained, saccharoidalto coarse-grained; porosity is associated especially with dolomitized fossils; has characteristic Huntington lithology	113.8-166.0

Section 6. Log of core from Indiana Geological Survey drill hole no. 11, Hancock County, Ind. (NE¼SE¼ sec. 28, T. 15 N. , R. 8 E.). Altitude, 852 ft. Modified from log by John B. Patton, August 1954.

Devonian System:	Depth
Middle Devonian rocks, 20. 1 ft cored:	(ft)
1. Dolomite, tan and brown, granular; bedding absent or indistinct; has crystalline calcite intercalations; vuggy in part; becomes very sandy in bottom few feet	50.2-70.3
Silurian System:	
Mississinewa Shale, 8. 5 ft:	
2. Limestone, argillaceous, silty, gray, very fine-grained, pyritic; bedding absent or indistinct	70.3-78.8
Louisville Limestone, 27.0 ft:	
3. Limestone, gray and tan, mottled and banded, fine-grained, stylolitic	78.8-105.8
Waldron Shale, 14. 7 ft:	
4. Limestone, argillaceous, gray, fine-grained, fossiliferous	105.8-107.3
5. Shale, gray and green-gray, calcareous, fossiliferous in part; bedding indistinct to shaly	107.3-120.5
Laurel Limestone, 45.0 ft:	
6. Limestone in several discernible units as much as a few feet thick; variably light gray, dark gray, gray and tan mottled, gray; cherty and noncherty; Fine grained to coarse grained; stylolitic in part	120.5-165.5
Osgood Formation? , 17.2 ft:	
7. Limestone, banded and mottled gray and tan to tan throughout, dense and argillaceous to coarse-grained; thin bedded in part	165.5-175.5
8. Shale and interbedded shale and limestone; shale is green, calcareous, fossiliferous, and thinly interbedded in part with argillaceous limestone	175.5-182.7

	Depth (ft)
Silurian System--Continued:	
Brassfield Limestone, 9.6 ft:	
9. Limestone, tan, dark gray-brown and tan, medium- to coarse-grained, glauconitic, fossiliferous and stylolitic in part; has wavy argillaceous partings	182.7-192.3
Ordovician System:	
Cincinnatian rocks, 28.0 ft cored:	
10. Shale, green-gray, calcareous, fossiliferous; has thin intercalations of fossiliferous limestone	192.3-195.4
11. Shale, grayish olive-green, noncalcareous	195.4-215.1
12. Shale and limestone, thinly interbedded, fossiliferous; shale is gray and calcareous; limestone is dark gray and coarse grained	215.1-220.3

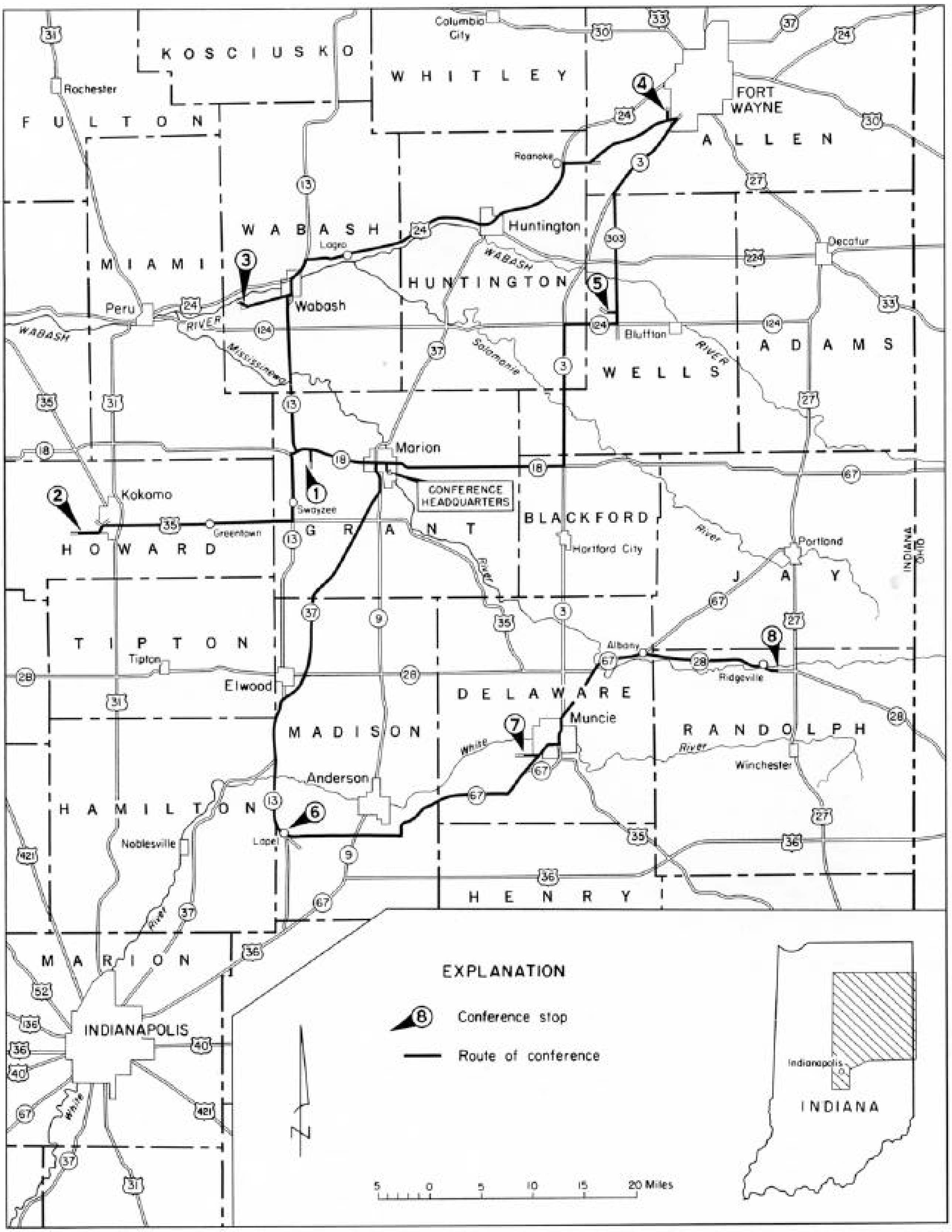

Figure 10.--Route map of the conference area.

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