

Geology of the Devonian Strata
of the
Falls of the Ohio Area,
Kentucky-Indiana:

Stratigraphy,
Sedimentology,
Paleontology,
Structure, and
Diagenesis



From the ANNUAL
FIELD CONFERENCE
of the
Geological Society
of Kentucky
held
September 10-11, 1993

By R. Todd Hendricks, Frank R. Etensohn, T. Joshua Stark, and Stephen F. Greb

KENTUCKY GEOLOGICAL SURVEY
Donald C. Haney, State Geologist and Director
University of Kentucky, Lexington

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COVER: Side view of enrolled specimen of *Phacops rana* from the Speed Member of the North Vernon Limestone, Sellersburg, Indiana.

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GEOLOGY OF THE DEVONIAN STRATA OF THE FALLS OF THE OHIO AREA, KENTUCKY-INDIANA: STRATIGRAPHY, SEDIMENTOLOGY, PALEONTOLOGY, STRUCTURE, AND DIAGENESIS

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INTRODUCTION

Nowhere on earth are fossiliferous rocks of Middle Devonian age as well exposed and as easily accessible as at the Falls of the Ohio River at Louisville, Kentucky, and Clarksville, Indiana (Figs. 1-2). For nearly two centuries, the Falls of the Ohio has been visited by countless professional and amateur paleontologists who have come to observe, collect, and describe the noteworthy fossil communities exposed in the Devonian limestones (Fig. 3) at the Falls.

No other single locality has yielded a greater number of fossil species than the Falls of the Ohio. Since 1820, some 600 species of fossils (including corals, stromatoporoids, brachiopods, crinoids, and other marine

invertebrates) have been reported from the Falls. However, Stumm (1964), in the most thorough study to date of Falls of the Ohio paleontology, determined approximately two-thirds of the coral species to be taxonomically redundant and therefore invalid. Nevertheless, over 200 species of fossils from a single locality is an impressive number.

Although the various fossil species found at the Falls can be found in many areas of North America, nowhere is their vertical and lateral context in the rock layers as easily observed. The vast area of the Falls and the predominantly bedding-plane exposures allow the observation of millions of individual fossil specimens. The fossil communities at the Falls are preserved virtu-

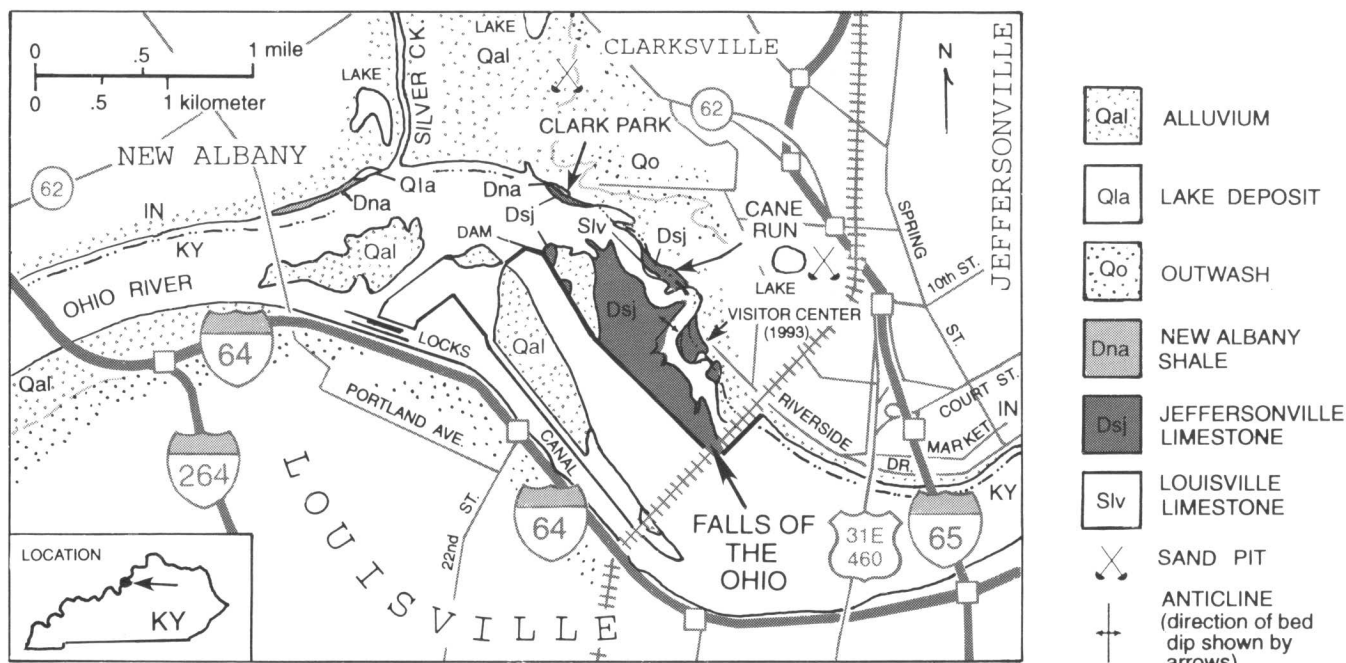


Figure 1. Map of the Falls of the Ohio showing the extent of the bedrock and unconsolidated sediments and the three exposures to be visited during this field conference. Modified from Greb and others (1993).

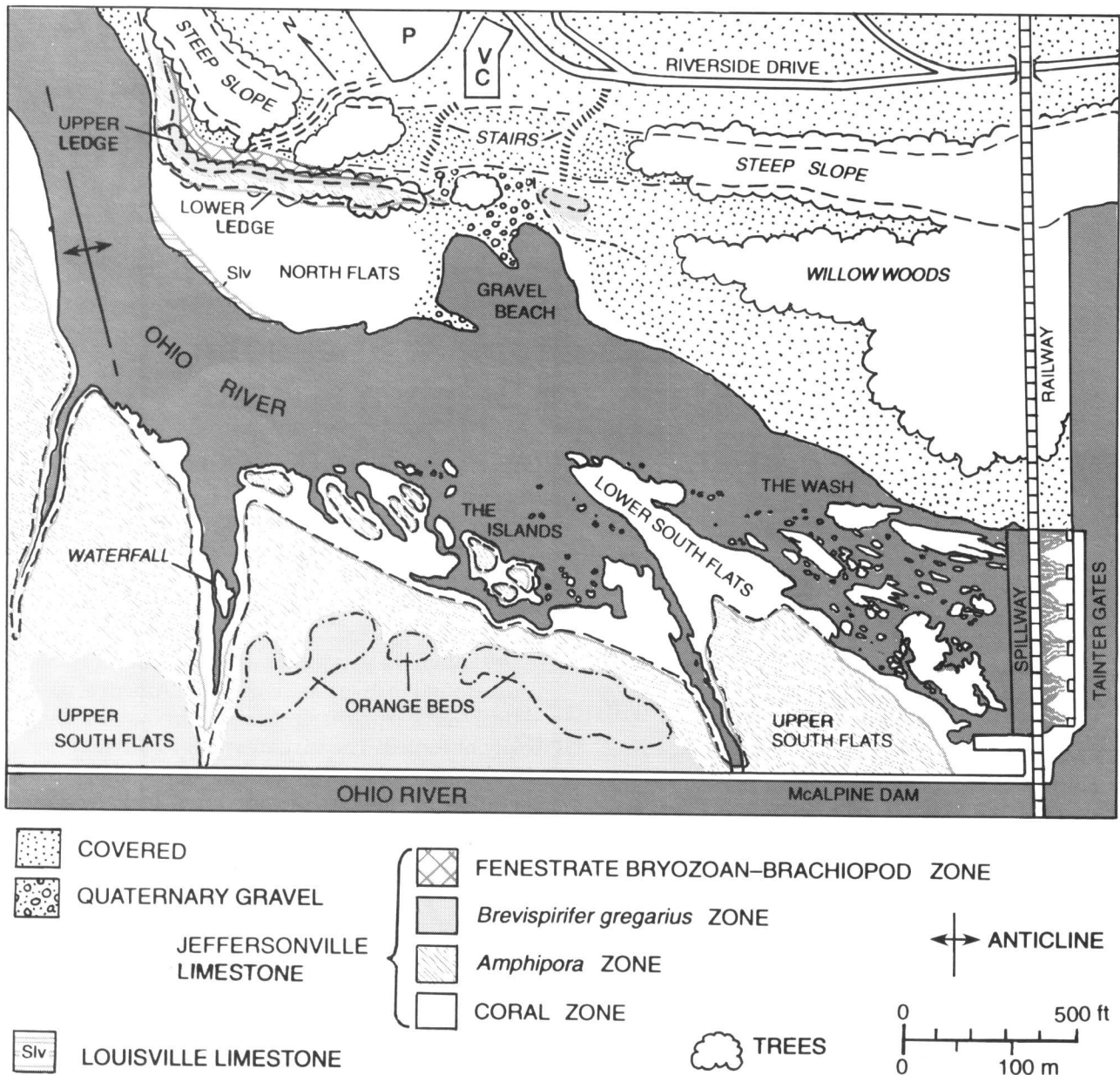


Figure 2. Geologic map of the Falls of the Ohio showing the areas of outcrop of the various rock units described in the text. From Greb and others (1993).

ally in situ, allowing rare insights into the paleoecological interactions of the residents of Devonian seas (see Kissling and Lineback, 1967). Cumulatively, these factors make the Falls of the Ohio a paleoecological resource that remains largely untapped.

Jeffersonville strata also form numerous hydrocarbon reservoirs in Indiana and Illinois, with the Geneva Dolomite Member being the most important reservoir rock. However, the stratigraphic relationships of the Devonian carbonates of the area remain widely misunderstood. For decades the Geneva was considered a formation separate from and older than the Jefferson-

ville Limestone (e.g., Perkins, 1963). In spite of compelling evidence presented by Droste and Shaver (1975), many stratigraphers still view the Geneva as a distinct, older formation.

This field conference will familiarize the participant with the fossils and strata exposed at the Falls of the Ohio. We will also observe surface exposures of the dolomitic facies of the Jeffersonville Limestone, including the Geneva Dolomite and Vernon Fork Members. Studying these outcrops should foster a better understanding of the depositional and diagenetic relationship between the Devonian rocks at the Falls and correlatives

in areas to the north. Finally, participants will visit three quarries in Clark and Scott Counties in Indiana (Fig. 4), which will allow further observation of the Devonian strata of the area as well as the collection of rock and fossil specimens.

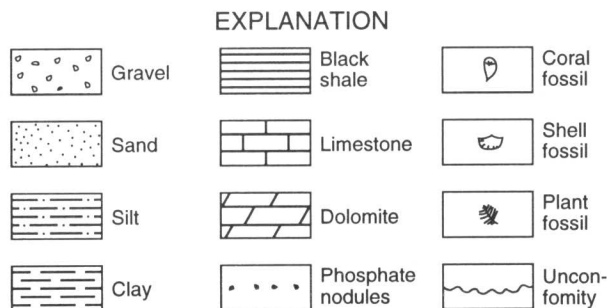
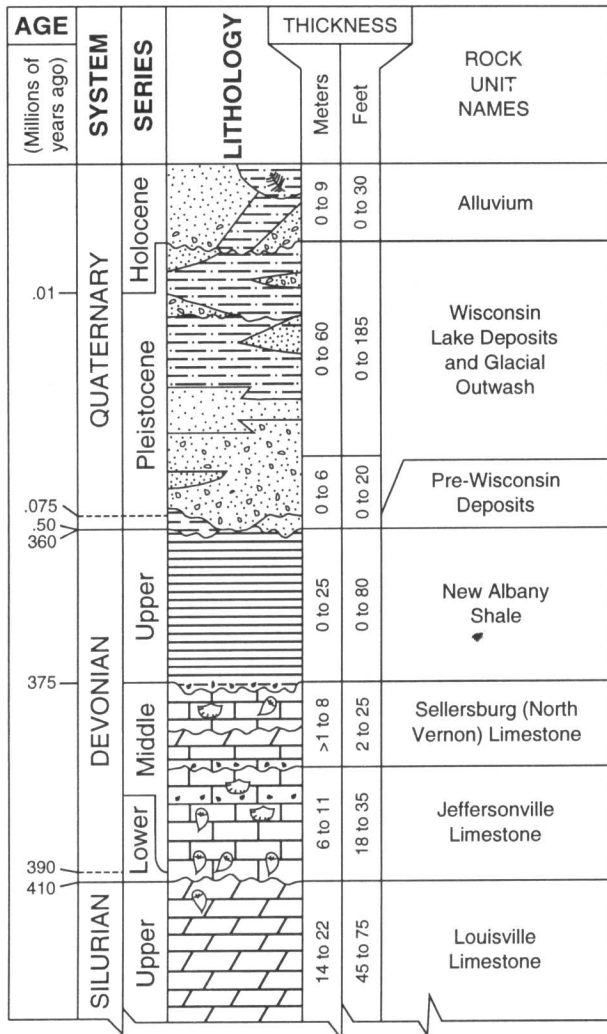


Figure 3. Stratigraphic column of rock units cropping out in the area of the Falls of the Ohio. From Greb and others (1993).

SAFETY REMINDER

The 1993 Geological Society of Kentucky Annual Field Conference was organized for professional geologists with decades of experience in safely examining quarries. Active quarries are *extremely* dangerous places; serious injuries or death may result from falls, drowning, falling rocks, heavy equipment, or high explosives. Furthermore, all of the quarries visited in this conference are private property, and unauthorized access is prohibited by law. In most cases, only experienced, professional geologists are allowed to visit these quarries. Therefore, amateur collectors are encouraged to avoid these areas. Excellent rock and fossil specimens may be collected in natural exposures and roadcuts in the Louisville area with little effort.

The fossil beds at the Falls of the Ohio are part of a National Wildlife Conservation area and an Indiana State Park and are therefore protected by both Federal and State laws. **ROCK AND FOSSIL COLLECTING IS NOT PERMITTED.** Also remember that the Falls area is subject to flooding. For your own safety, read warn-

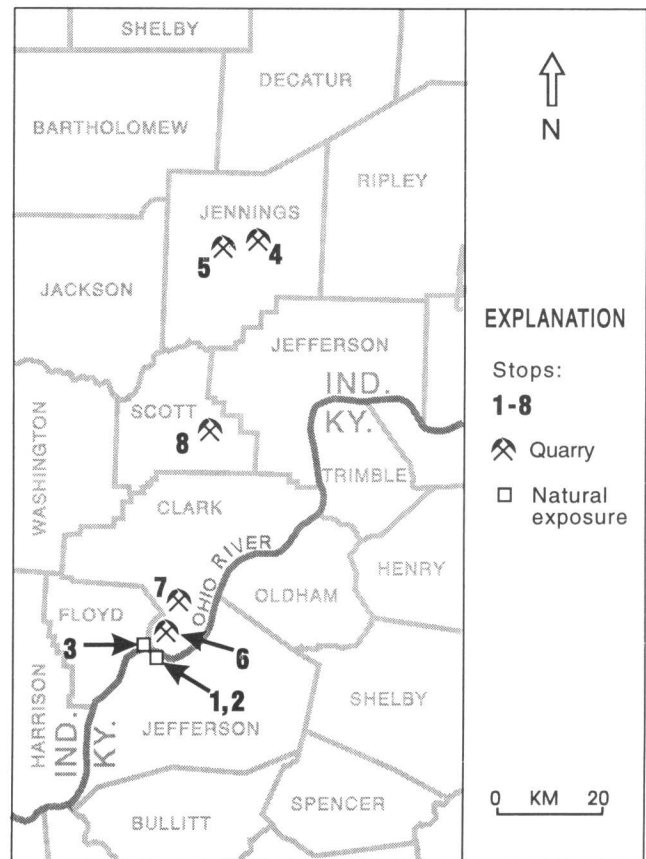


Figure 4. Map of southeastern Indiana and adjacent Kentucky showing the location of stops to be visited during field conference.

ing signs in the parking area before walking down to the fossil beds.

ORIGIN OF THE FALLS OF THE OHIO

The Falls of the Ohio is not actually a waterfall as the name implies, but a limestone bedrock ridge that extends across the channel of the Ohio River between Louisville, Kentucky, and Clarksville and Jeffersonville, Indiana. This bedrock ridge formed a series of natural rapids across the river channel prior to the completion of McAlpine Dam and locks. For many years, the rapids at the Falls of the Ohio were the only natural barrier to navigation along the entire 981-mile route of the Ohio River. In fact, the principal reason the Louisville area was initially settled was because the rapids at the Falls forced boats to unload cargo and passengers. In modern times, the completion of the canal and locks has allowed more cargo to pass through McAlpine Dam than through the Panama Canal (Powell, 1970).

During the Pleistocene, the Ohio River Valley was repeatedly scoured by intense floods of glacial meltwater and subsequently filled with glacial outwash and fluvial and lacustrine deposits. Time and again, the river meandered in its valley, cutting new channels while eroding pre-existing sediments and bedrock. The limestone bedrock ridge that now forms the rapids at the Falls of the Ohio was probably created by these episodes of meltwater erosion, valley filling, and river meandering.

At the end of the Wisconsinan glacial interval, the limestone bedrock ridge at the Falls was buried by unconsolidated sediments (predominantly glacial outwash). The Ohio River later meandered to a position overlying the ridge. In time, the river cut through the unconsolidated sediments, exhuming the limestone bedrock ridge and its remarkable fossils.

Since the Ohio River began cutting a new channel overlying the limestone bedrock ridge at the Falls, approximately 50 feet of unconsolidated sediment and from 10 to 20 feet of bedrock have been removed (Powell, 1970). In fact, the erosional processes that first formed the Falls of the Ohio are continuously contributing to its destruction.

STRUCTURAL GEOLOGY OF THE FALLS OF THE OHIO AREA

For good reason, the vast exposures of fossiliferous limestone at the Falls of the Ohio have received a great deal of attention from paleontologists. However, an increasingly intriguing story is emerging concerning the

structural geology of the Falls area. The following discussion is based upon the limited structural information available to the authors.

Regional Structural Geology

Aeromagnetic, gravity, seismic, and drilling data indicate that the Falls of the Ohio is situated along the northern edge of a large, high-relief, basement mafic complex termed the Louisville Accommodation Structure (Stark, 1990, in press). This feature separates structurally lower areas to the south (the East Continent Rift Basin; Drahovzal and others, 1992) from those to the north (the English Graben; Stark, 1990, in press).

In the 1950's, statewide aeromagnetic surveys of Indiana first suggested the presence of the Louisville Accommodation Structure when a major positive magnetic anomaly was detected in southern Indiana and adjacent northern Kentucky (see Fig. 5). Separated from a magnetic minimum by high-gradient linear margins, this anomaly is one of the most prominent aeromagnetic features in Indiana.

Structural data led Henderson and Zeitz (1958) to speculate that the southern Indiana aeromagnetic anomaly represents "a large, mafic basement intrusive" (p. 32). The mafic composition of this structure was later verified with the drilling of the DuPont No. 1 Wadd (Fee) deep test in Jefferson County, Kentucky. Fractured, medium-grained gabbroic rocks were penetrated beneath a normal Paleozoic sedimentary section at a depth of 5,954 feet. Later, Stark (1990, in press) referred to the structure delineated by aeromagnetic data and associated with the mafic complex penetrated by the DuPont test as the Louisville Accommodation Structure.

Recent industry seismic data indicate that the Louisville Accommodation Structure possesses significant structural relief at depth. While drilling has placed the top of the mafic complex near Louisville at about 5,954 feet, time-to-depth conversions from seismic interpretation indicate depths to crystalline basement in the area west of the Louisville Accommodation Structure to be in excess of 20,000 feet (Rowley, 1992, oral commun.). This structurally lower area is referred to as the English Graben (Stark, 1990, in press; Dickas and others, 1992).

The COCORP IN-1 seismic line crossed approximately 38 kilometers of the English Graben. Pratt and others (1989) noted the existence of the structure and reported that "dipping reflectors and a ramplike feature indicate deformation in the layering, perhaps indicative of a fundamental lateral change" (p. 506).

The English Graben is characterized by an aeromagnetic minimum and a negative isostatic gravity anomaly.

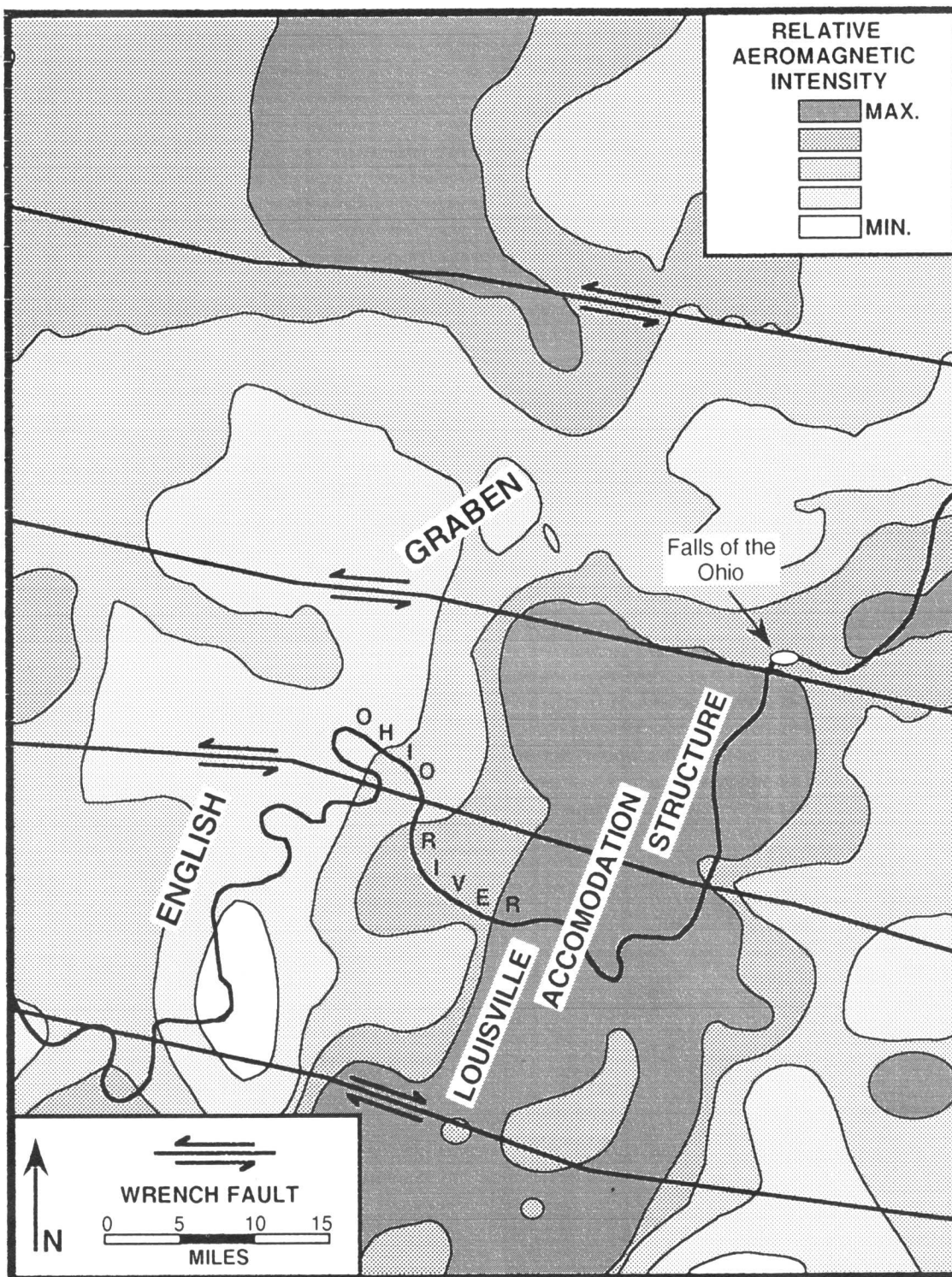


Figure 5. Aeromagnetic analysis of the English Graben/Louisville Accommodation Structure area. After Stark (in press).

ly, suggesting the presence of a thick sedimentary package. As much as 14,000 feet of additional sedimentary fill may be present in the English Graben; these sediments are likely of Precambrian age and related to the recently named Proterozoic Middle Run Formation (Shrake and others, 1990; Drahovzal and others, 1992).

Potential field data analysis (Stark, 1990, in press) (see Fig. 5) indicates that the Louisville Accommodation Structure, the English Graben, and the East Continent Rift Basin are offset by several northwest-trending, predominantly left-lateral wrench-fault systems. This wrench faulting is likely a product of Keweenawan transtension and Grenvillian transpression, with lateral offsets exceeding several kilometers. One such left-lateral strike-slip fault zone crosses the northern edge of the Louisville Accommodation Structure in the immediate Falls of the Ohio area.

Although these structures probably evolved in the Precambrian, modern east-west compression may tend to reactivate the wrench faults. In a study of a series of earthquakes in Meade County, Kentucky, the most energetic of which occurred on January 24, 1990, Street and others (1990) concluded that "the distribution of aftershock data would suggest that the northwest-trending nodal plane is more apt to be the rupture plane (i.e., a left-lateral strike-slip event)" (p. 108). At least six earthquake epicenters have been reported adjacent to the Falls of the Ohio (Braile and others, 1982). These events may have been triggered by focal mechanisms similar to those of the Meade County earthquakes.

Together, the available structural data indicate that the Falls of the Ohio is probably situated along a major, basement, left-lateral, strike-slip fault zone that crosses the northern edge of the Louisville Accommodation Structure near Louisville. Although the strike-slip fault zone originated in the Precambrian, seismological information indicates modern reactivation of this structure.

Local Structure

Strata in northwestern Kentucky and adjacent Indiana generally dip a few feet per mile to the west. However, strata in the northwestern part of the Falls of the Ohio (downstream from the mouth of Cane Run Creek) dip to the northwest, while strata in the eastern part of the Falls (adjacent to the Pennsylvania Railroad Bridge) dip to the southeast. For this reason, Kepferle (1974) mapped an anticline in the Ohio River at the Falls (see Fig. 2). Because of this structure, the Louisville Limestone (the lowest strata exposed at the Falls at low water) can be seen only in the central area of the fossil beds at the Falls of the Ohio.

Numerous joints crosscut the bedrock at the Falls of the Ohio. Both open and calcite-filled joints can be seen in the limestone strata when water levels permit. Three sets of joints are present in the river bed. The dominant joints trend approximately N5°E; subordinate joints trend approximately N40°W and N85°W.

Open joints, some with as much as a foot or more of apparent extension, are present in the lower layers at the Falls (Fig. 6). The bedrock surfaces along such joints have sharp, angular, fitted edges that show little evidence of solution enlargement or erosion. Silicified fossil corals do not stand in considerable relief along the walls of the joints as they do in (unequivocal) solution cavities present in the *Amphipora ramosa* zone in the Islands area (Fig. 7). Furthermore, some open joints crosscut such erosional features as potholes, suggesting both a more recent and a different origin for the extension along the joints.

Although the unusually great extension between the joint surfaces may be due to physical or chemical erosion or even slumping of large limestone blocks into the

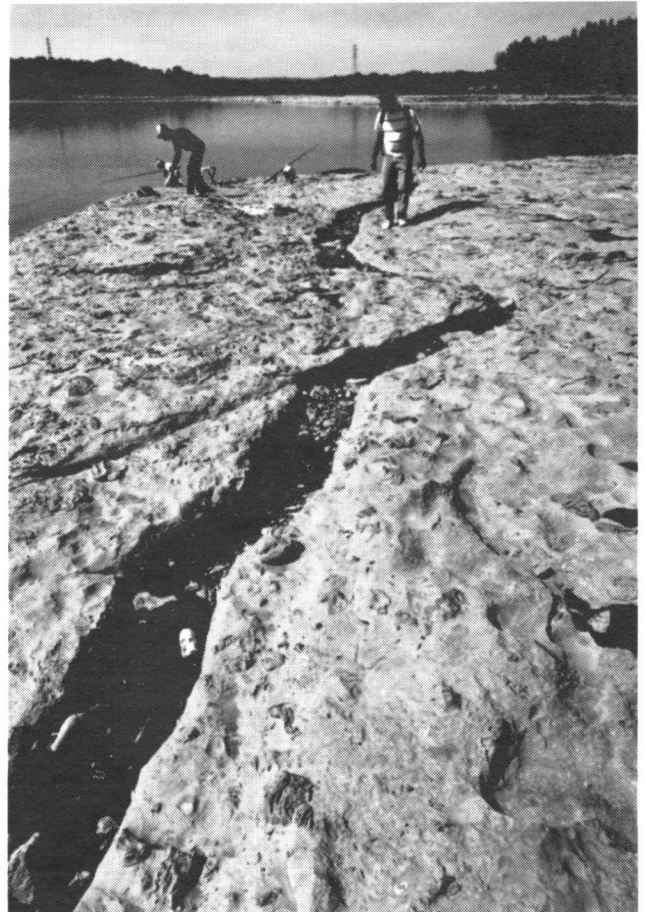


Figure 6. Large open fracture in the bedrock at the Falls of the Ohio.

river channel, the ongoing structural activity (extension) in the area of the Falls may be a contributing process. At least six earthquake epicenters have been reported adjacent to the Falls of the Ohio (Braile and others, 1982). Possibly, the open joints at the Falls formed in the relatively recent geological past when earthquakes occurred along the northern margin of the Louisville Accommodation Structure. The anticline mapped by Kepferle (1974) in the river bed may be a product of the same or similar events.

GENERAL STRATIGRAPHY

The Devonian rocks exposed in the conference area include the Jeffersonville Limestone, the North Vernon Limestone, and the New Albany Shale, in ascending order (Droste and Shaver, 1986a-g) (Fig. 3). The Jeffersonville Limestone unconformably overlies Silurian strata, consisting of either the Louisville Limestone or Wabash Formation. The Louisville Limestone and Wabash Formation will not be stressed in this discussion. General stratigraphic information concerning these two units can be found in Shaver and others (1986).

The Jeffersonville Limestone (Emsian and Eifelian) was named by Kindle (1899) for the fossiliferous limestone exposures at the Falls of the Ohio near Jeffersonville, Indiana (Stop 1). However, since the completion of the dam and locks, most of this important outcrop has been permanently flooded. Bedrock is no longer exposed in the river bed at Jeffersonville, and the lime-



Figure 7. Silicified corals standing in relief on the walls of solution cavities developed in the *Amphipora ramosa* zone at the Falls of the Ohio.

stone bedrock ledges that are still accessible are entirely within the cities of Louisville, Kentucky, and Clarksville, Indiana.

Numerous different stratigraphic workers have proposed numerous different zonal divisions of the Jeffersonville Limestone at the Falls of the Ohio (e.g., Oliver, 1960; Perkins, 1963; Stumm, 1964; Conkin and Conkin, 1972, 1976). Of these, the informal five-fold zonation of Perkins (1963) remains the most widely used, paleontologically accurate, and sedimentologically meaningful.

Stratigraphic nomenclature for the Jeffersonville Limestone is complicated by some workers using the various fossil zones in combination with or in place of properly defined lithostratigraphic units such as the Vernon Fork and Geneva Dolomite Members. In most cases, the fossil zones were never intended to be used as formal stratigraphic units, and are not suggested to be so in this discussion. In fact, fossil zones cannot, by definition, be formal lithostratigraphic units. Formations and members are defined on the basis of distinctive lithologies, not faunal constituents. Therefore, the use of any of the various biozones of the Jeffersonville Limestone to delineate particular rock units should be abandoned, and lithostratigraphic members should be named. However, this action is yet to be taken. Therefore, Perkins' (1963) zonation of the Jeffersonville Limestone will reluctantly be used in this report.

In the conference area, the Jeffersonville Limestone includes a southern limestone facies and a northern dolostone and dolomitic limestone facies. The southern limestone facies comprises the five biozones of Perkins (1963) exposed at the Falls of the Ohio. These are the coral, *Amphipora ramosa*, *Brevoispirifer gregarius*, fenestrate bryozoan-brachiopod, and *Paraspirifer acuminatus* zones, in ascending order. The northern dolomitic facies of the Jeffersonville Limestone as exposed at Hayden and North Vernon includes the Geneva Dolomite Member, an unnamed member of dolostone and dolomitic limestone (approximately equivalent to the *Amphipora ramosa* zone), the Vernon Fork Member, and an upper cherty, fossiliferous limestone (the *Paraspirifer acuminatus* zone).

Coral zone strata are typically medium- to dark-gray and grayish-brown, abundantly fossiliferous limestones. Packstones, grainstones, and rudstones are the predominant limestone textures. Solitary and colonial corals, mound-shaped stromatoporoids, and pelmatozoan debris are common to very abundant. Mat-shaped stromatoporoids, brachiopods, and bryozoans are much less common than in overlying zones.

The coral zone can be traced from outcrops a few miles south of Louisville northward to southern Jennings, Jackson, and Lawrence Counties in Indiana (Per-

kins, 1963). North of the outcrop area of rocks of the coral zone, the stratigraphic position between the Silurian Louisville and Wabash carbonates and the *Amphipora ramosa* zone of the Jeffersonville Limestone is occupied by the Geneva Dolomite Member.

In the southern conference area near the Falls of the Ohio, *Amphipora ramosa* zone rocks include abundantly fossiliferous, medium-gray limestones; skeletal packstones and grainstones are the predominant textural types. The small, branching, cylindrical stromatopoid, *Amphipora ramosa* (App. A: Plate 5 [Fig. 1]), is common to abundant in these rocks, but recognition of the taxon is best accomplished in thin-section study. Although solitary and colonial corals are common in the *Amphipora ramosa* zone, such fossils are considerably less abundant than in the underlying coral zone. Mat-shaped, encrusting stromatopoids abound, and probably acted locally as sediment-binding agents.

Amphipora ramosa zone sediments are present throughout the conference area. North of the Falls of the Ohio, in Jennings County, Indiana (Stops 4 and 5), diagenetically altered *Amphipora ramosa* zone rocks overlie the Geneva Dolomite Member. Such strata commonly include light- to medium-grayish-brown, fossiliferous, partially sucrosic dolomitic limestones and calcareous dolostones. Packstones and wackestones are probably the dominant sedimentary textures, although recrystallization has obscured many fossils.

Brevispirifer gregarius zone lithologies include medium-gray, abundantly fossiliferous limestones (packstones and grainstones). In addition to containing vast numbers of the small spiriferid that gives the unit its name, the *Brevispirifer gregarius* zone also contains abundant pelmatozoan debris, charophyte oogonia, and large snails. Corals are generally smaller and much less abundant than in the coral and *Amphipora ramosa* zones. Chert is a minor constituent in the *Brevispirifer gregarius* zone in the southern conference area, but to the north, at Stop 8 in Scott County, Indiana, the unit is quite cherty and argillaceous. The *Brevispirifer gregarius* zone pinches out rapidly north of Scottsburg, and its position is occupied by the lower part of the Vernon Fork Member.

Overlying the *Brevispirifer gregarius* zone, the fenestrate bryozoan-brachiopod zone comprises light-grayish-brown, abundantly fossiliferous, carbonate packstones and grainstones with nodules and stringers of white chert near the base of the unit. Crinoids, blastoids, bryozoans, brachiopods, and corals are the predominant fossil constituents; *Atrypa*, strophomenids, and small spiriferids abound, but *Brevispirifer* and *Paraspirifer* are absent. The fenestrate bryozoan-brachiopod zone can be traced north from the Falls of the Ohio

to Jennings County, Indiana. At Stops 4 and 5 the unit is absent and its stratigraphic position is occupied by the upper part of the Vernon Fork Member of the Jeffersonville Limestone.

The *Paraspirifer acuminatus* zone was characterized by Perkins (1963) as being faunally and lithologically similar to the underlying fenestrate bryozoan-brachiopod zone, but with the addition of the large spiriferid *Paraspirifer acuminatus* (App. A: Plate 10 [Figs. 3A-B]). Like the latter unit, the former includes light-grayish to yellowish-brown, fossiliferous bryozoan-, pelmatozoan-, and brachiopod-rich packstones and grainstones. The *Paraspirifer acuminatus* zone is the most widespread of all the Jeffersonville Limestone biozones recognized at the Falls of the Ohio, with similar lithologies present everywhere in the conference area.

The Geneva Dolomite was named by Collett (1882) as the Geneva Limestone for exposures along the Flatrock River, near Geneva, Indiana. Droste and Shaver (1975) concluded that the Geneva Dolomite is a northern facies of the lower Jeffersonville exposed at the Falls of the Ohio, and subsequently lowered the Geneva from formation to member rank, assigning the member to the Jeffersonville Limestone.

The Geneva Dolomite Member includes light-grayish-brown to chocolate-brown (often laminated and banded dark-brown), fine- to medium-crystalline, porous, variably fossiliferous dolostones. Original depositional textures are generally obscured by diagenesis. Beds are generally massive in the lower part of the Geneva and thinner bedded in the upper part. Fossils in the conference area are common to abundant, but are preserved as internal casts and molds. Often, recrystallization has further obscured morphological features. Thus, taxonomically important characteristics are typically absent. Fossils include abundant solitary and colonial corals and stromatopoids. White to light-yellowish-brown calcite masses and crystals commonly fill vugs and fossil molds. Bands and nodules of light-colored chert are present in Jennings County, Indiana (Stop 4); fossil preservation is typically better in the cherts than in the dolostones.

The dark-brown color, laminations, and color banding of the Geneva Dolomite are due to organic material resembling heavy hydrocarbons (Leninger, 1955). In fresh exposures, the Geneva is typically dark chocolate brown, but the organic residue rapidly oxidizes, and weathered outcrops are light yellowish brown, light gray, or white.

Texturally, the Geneva Dolomite resembles the Jeffersonville Limestone coral zone exposed at the Falls of the Ohio. Both units include dark-brown, carbonaceous lithologies with abundant corals and stromato-

poroids. Fossils in these units are quite similar, although specific identification of Geneva corals and stromatoporoids is complicated by the lack of internal structures. The rostroconch *Hippocardia cunea* (App. A: Plate 5 [Figs. 3A–B]) is common at the Falls of the Ohio, and is the most easily recognized fossil in the Geneva Dolomite Member (Fig. 8). Furthermore, moldic specimens of *Amphipora ramosa* are abundant in the uppermost bed of the Geneva Dolomite Member at North Vernon (Stop 4). This bed is immediately subjacent to the lighter colored dolomitic limestone identified as the *Amphipora ramosa* zone by Perkins (1963) and Droste and Shaver (1975).

The faunal and lithologic evidence supports the view of a Geneva-Jeffersonville facies relationship. Moreover, the lithologic differences between the Geneva and lower Jeffersonville rocks at the Falls of the Ohio are rooted predominantly in diagenetic processes rather than depositional or temporal variations.

The Vernon Fork Member of the Jeffersonville Limestone was named by Droste and Shaver (1975) for exposures in the area of the Vernon Fork of the Muscatatuck River near North Vernon, Indiana. Prior to that time the unit was generally called the “laminated beds” of the Jeffersonville Limestone. The Berry Materials Quarry at North Vernon (Stop 4) was named the principal reference section for the Vernon Fork Member. In this section, Vernon Fork rocks overlie the *Amphipora ramosa* zone and underlie the *Paraspirifer acuminatus* zone. Detailed sedimentology and petrography of the “laminated beds” were studied by Perkins (1963).

In the conference area, Vernon Fork lithologies include laminated, commonly brecciated, unfossiliferous dolomitic mudstones with mudcracks, flat pebble con-

glomerates, and relict evaporites (Figs. 9–10). Unfossiliferous, bioturbated, dolomitic mudstones are also present.

Perkins (1963) noted a rough correlation between the distribution of the Vernon Fork Member (“laminated beds”) and the Geneva Dolomite in Indiana, which he attributed to shallower water having been present over the pre-existing “Geneva Platform.” Later, Droste and Shaver (1975) recognized the correlation of the Geneva Dolomite and lower Jeffersonville Limestone, and stated that Geneva sediments were most likely dolomitized by hypersaline fluids during deposition of the Vernon Fork Member. The presence of relict evaporites in the Vernon Fork Member strengthens this interpretation, because evaporite precipitation follows dolomite formation in modern Persian Gulf sabkhas (Müller and others, 1990).

The Vernon Fork Member is laterally continuous with part or all of the *Amphipora ramosa*, *Brevispirifer gregarius*, and fenestrate bryozoan-brachiopod zones at the Falls of the Ohio. In the conference area, the Vernon Fork Member is present north of southern Jennings County, Indiana. For a more complete discussion of Vernon Fork and Jeffersonville lithologies, see Droste and Shaver (1975) and Perkins (1963).

The North Vernon Limestone (Eifelian and Givetian) was named by Borden (1876) for blue and gray limestones exposed between the “Corniferous” (Jeffersonville) Limestone and the New Albany Shale near North Vernon, Indiana. The North Vernon Limestone is synonymous with the Sellersburg Limestone of Kentucky usage, and comprises the Speed, Silver Creek, and Beechwood Members. In the conference area, the North Vernon Limestone unconformably overlies the Jeffersonville Limestone and is unconformably overlain by the New Albany Shale. The Beechwood Member itself unconformably overlies the other North Vernon rocks in the conference area.

The Speed Member (Eifelian) of the North Vernon Limestone was first named the “Speeds Limestone” by Sutton and Sutton (1937) for exposures in Speed’s Quarry near Sellersburg, Indiana. Speed lithologies include thin-bedded, argillaceous, bioclastic, crinoid-, brachiopod-, and bryozoan-rich limestone, predominantly of packstone texture. The Speed is not present at the Falls of the Ohio, presumably because of nondeposition of the Speed lithology (Droste and Shaver, 1986f). In the conference area, the unit is generally less than 5 feet thick.

The Silver Creek Limestone (Eifelian) was named by Siebenthal (1901) for exposures along Silver Creek near the Falls of the Ohio. The Silver Creek Member possesses two basic lithologies: a lower, massive, biotur-



Figure 8. The rostroconch *Hippocardia cunea* and a large solitary rugosan in the Geneva Dolomite Member of the Jeffersonville Limestone (Stop 5).

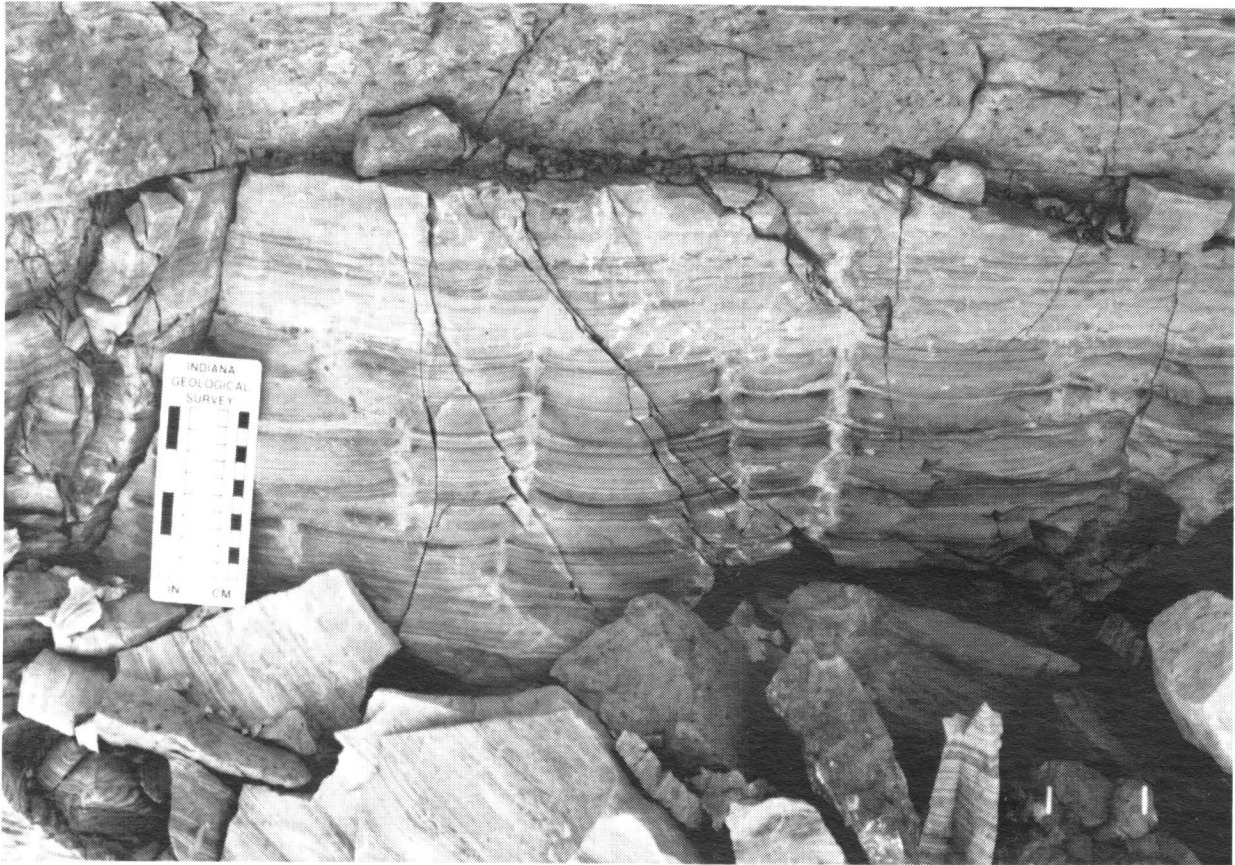


Figure 9. Laminated, mudcracked dolomiticrites of the Vernon Fork Member of the Jeffersonville Limestone (Stop 4).

bated, variably fossiliferous, argillaceous, dolomitic lime mudstone with wackestone and packstone layers; and an upper unit that closely resembles the lower lithology but with the addition of abundant chert nodules and stringers. Fossils include locally abundant brachiopods, corals, and trilobites. The Silver Creek and Speed Members possess a facies relationship and are gradational and conformable where both are seen in the same exposure (Droste and Shaver, 1986e). The Silver Creek is thickest in central Clark County, Indiana, where sections as thick as 26 feet are present (Whitlatch and Huddle, 1932). The unit thins to the north as the Speed Member thickens, and no significant thickness of Silver Creek is present north of southern Scott County, Indiana. However, lithologically similar beds are present in the Speed Member (Droste and Shaver, 1986e).

The Beechwood Member (Givetian) (Butts, 1915) was named for outcrops in the area of Beechwood Station in Jefferson County, Kentucky. The Beechwood unconformably overlies various older rocks. In the conference area these include only the Silver Creek and Speed Members of the North Vernon Limestone. The Beechwood is typically an abundantly fossiliferous,

usually light-colored, bioclastic (crinoidal) limestone, although glauconitic lithologies exist. The base of the Beechwood is commonly marked by a prominent lag zone with quartz sand, phosphatic nodules, and fish bone fragments (App. A: Plate 12 [Fig. 5]). Fossils include abundant pelmatozoan debris, corals, bryozoans, and trilobites. Some small-scale crossbedding is present in the Scott County Stone Company Quarry (Stop 8). The Beechwood Member is the most widespread Devonian carbonate unit in southeastern Indiana and adjacent Kentucky, nearly everywhere underlying the New Albany Shale.

The New Albany Shale (Devonian–Mississippian) unconformably overlies the Beechwood Limestone in the conference area, although the Beechwood is subject to dissolution and is locally absent. The presently used New Albany stratigraphy was developed by Lineback (1968, 1970) and includes five members, which are, in ascending order, the Blocher Member, consisting of dolomitic black shales, dolostones, and dark-gray dolomitic mudstones and siltstones; the Selmier Member, consisting of greenish-gray shales with interbeds of dark-gray shales and siltstones; the Morgan Trail Member, consisting of fissile, black, pyritic shale; the Camp

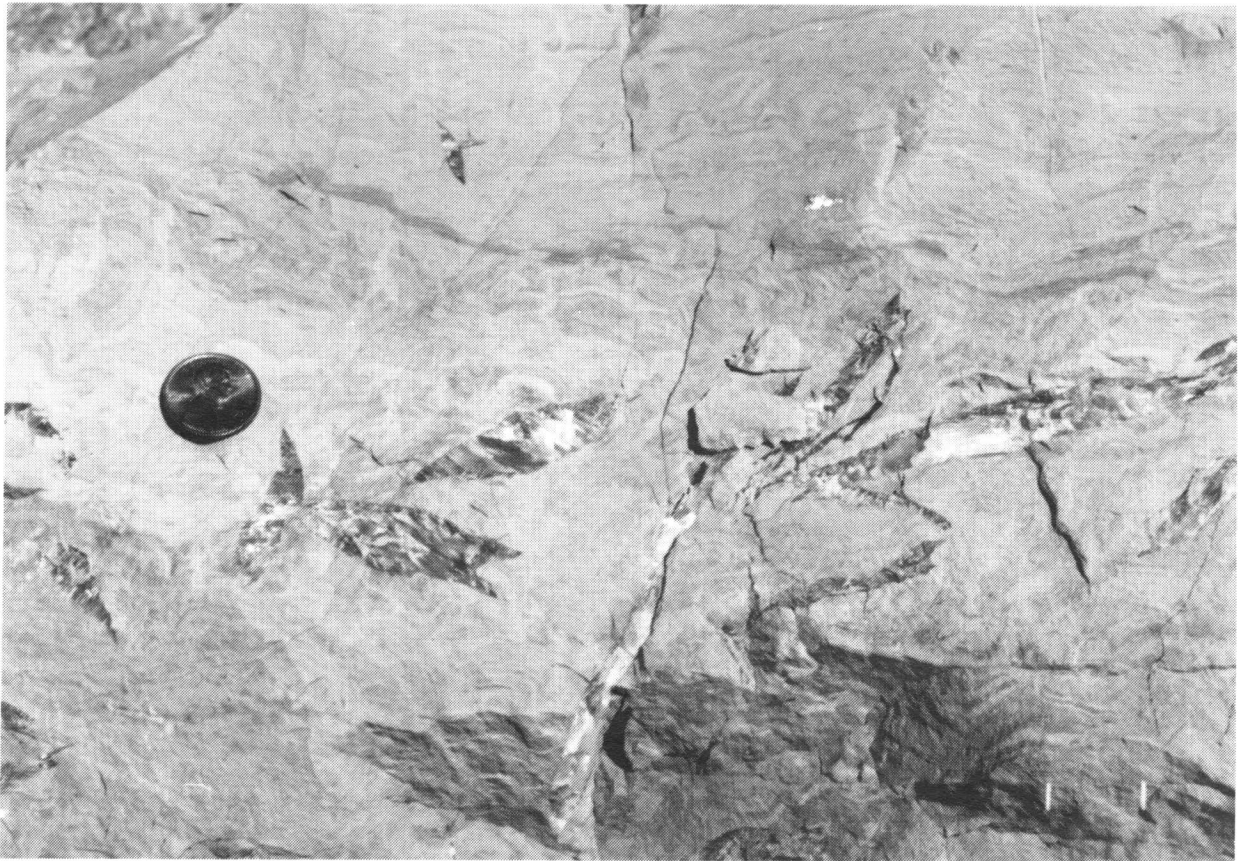


Figure 10. Calcite pseudomorphs after gypsum from the Vernon Fork Member of the Jeffersonville Limestone (Stop 4).

Run Member, consisting of greenish-gray to olive-gray shales and mudstones interbedded with fissile black shales; and the Clegg Creek Member, consisting largely of fissile black shales with a few greenish-gray shale horizons. Figure 11 is a composite of the type section from Floyd, Clark, and Jennings Counties, Indiana.

Although all five members are present in the western Kentucky subsurface (Woodrow and others, 1988), only the Blocher, Camp Run, and Clegg Creek are exposed at the surface in Kentucky (Ettensohn and others, 1989). The two members missing from the Kentucky outcrop, the Selmier and Morgan Trail, will be seen at Stop 4 on Friday.

The biostratigraphy of the New Albany was also initially done by Lineback (1968, 1970), but re-examination of conodonts from the shales relative to the *Protosalvinia* zone (see Hasenmueller and others, 1983b) now suggests that most of the New Albany units were zoned too high (Ettensohn and others, 1989). Figure 12 shows the revised biostratigraphy and indicates that the Blocher Member is largely late Middle Devonian (Givetian) in age, the Selmier and Morgan Trail Members are early Late Devonian (Frasnian) in age, and that the Camp Run and Clegg Creek Members are largely later

Late Devonian (Fammenian) in age, although the upper few feet of complete Clegg Creek sections are earliest Mississippian (Tournaisian) in age. *Protosalvinia* is a possible alga, which is found in a distinct biostratigraphic marker horizon in the black shales throughout most of the eastern United States (Hasenmueller and others, 1983b). The lithostratigraphic, biostratigraphic, and structural relationships of the New Albany, Chattanooga, and Ohio black shales in Kentucky and adjacent states are shown in Figure 12.

ROADLOG Friday Morning, September 10, 1993

Assemble in the parking lot of the Day's Inn, 101 East Jefferson Street, Louisville, Kentucky. We need to depart by 8:30 a.m. or shortly thereafter in order to have time to visit all of the planned stops.

Mile

- 0.00 Leave Day's Inn parking lot. Turn right (west) onto Jefferson Street. Stoplight (First Street) ahead. Continue straight on Jefferson Street.
- 0.10 Stoplight. Turn right onto Second Street.

Geology of the Devonian Strata of the Falls of the Ohio Area, Kentucky-Indiana

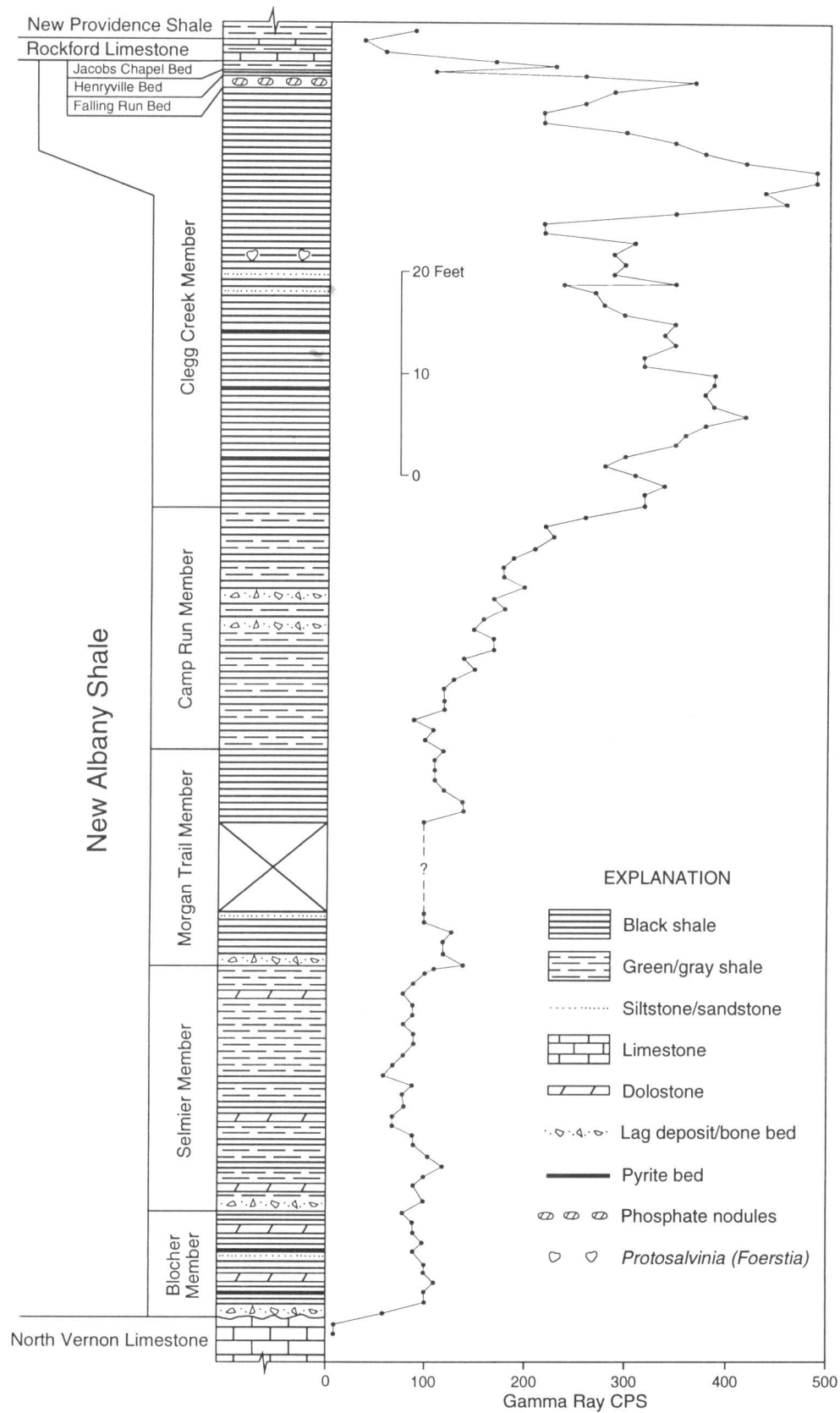


Figure 11. Composite stratigraphic column of the New Albany Shale in the conference area (modified from Peter T. Goodman's original drawing).

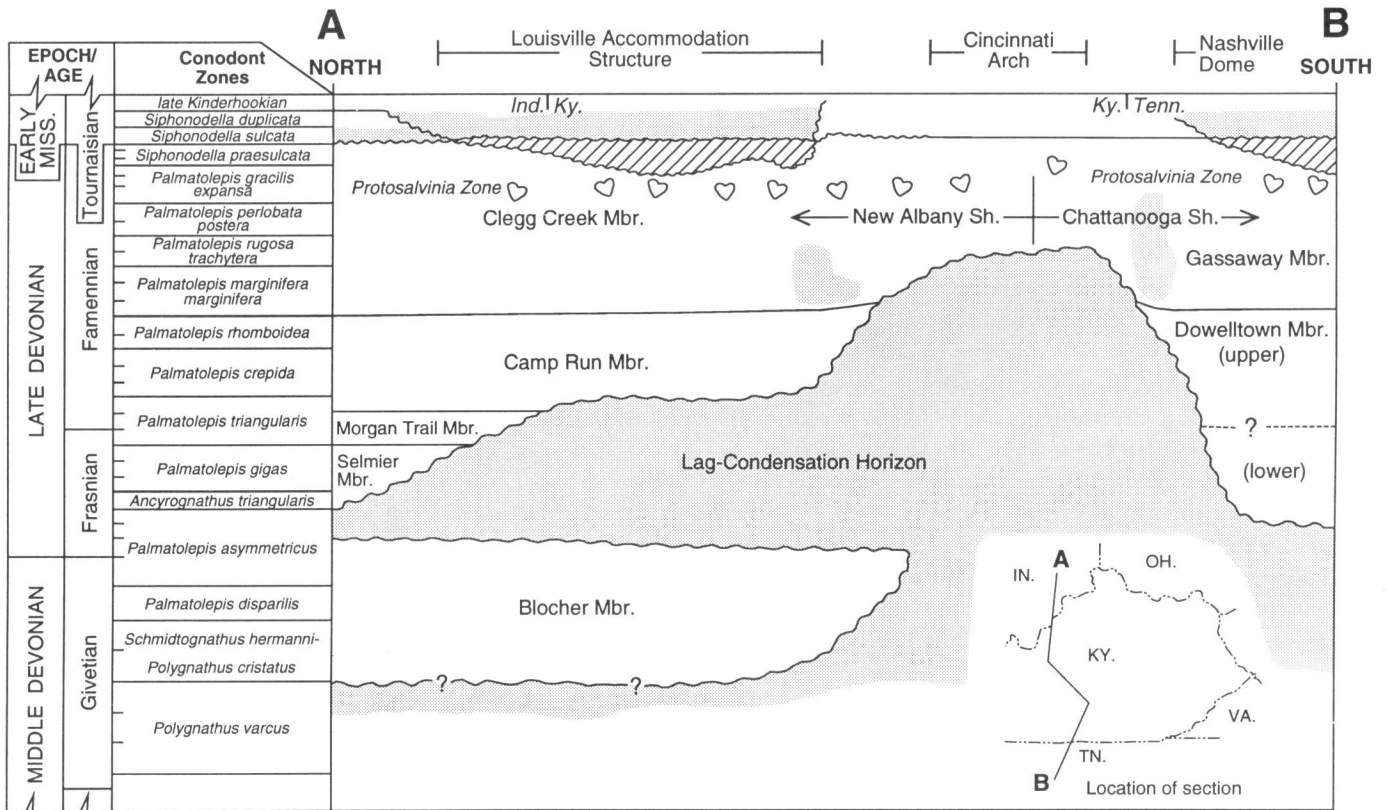


Figure 12. Biostratigraphy of the New Albany Shale in west-central Kentucky and adjacent areas of Indiana and Tennessee in comparison with the Chattanooga and Ohio Shales. Stippled areas represent lag-condensation zones; "time-rich" horizons represented by thin, sediment-starved layers or bone beds. Cross-hatched areas represent missing section, generally on or near structural features. ("A" represents Stop 4.) Adapted from Etensohn and others (1989).

- 0.20 Stoplight. Market Street. Continue straight on Second Street.
- 0.30 Stoplight. Main Street. Continue straight ahead, cross Clark Bridge over Ohio River.
- 0.60 Fountain in Ohio River at left.
- 1.40 Jeffersonville exit. Exit right at end of bridge, then veer right at yield sign.
- 1.60 Stop sign. Turn right onto Market Street.
- 1.75 Floodwall gate. Continue straight ahead on Market Street.
- 1.78 Stop sign. Turn right onto Riverside Drive.
- 2.30 Cross under railroad bridge.
- 2.40 Parking lot at left.
- 2.50 Parking lot, Falls of the Ohio State Park Visitors Center (Stop 1).

Stop 1

Falls of the Ohio, northern edge of Louisville, Jefferson County, Kentucky, and southern edge of Clarks-ville, Clark County, Indiana. New Albany Quadrangle. Carter coordinate location 19- and 20-V-45. Clark Military Grant Sections 1 and 8. **Note: Collection of rocks**

and fossils at the Falls of the Ohio is now prohibited by State and Federal law. No hammers allowed.

Stop Description

The bedrock exposed at the Falls of the Ohio (including the outcrop just west of the mouth of Cane Run Creek) encompasses approximately 1 foot of Louisville Limestone, a complete (35 feet thick) section of Jeffersonville Limestone, and a thin, largely covered section of the Silver Creek Member of the North Vernon Limestone. Unconsolidated sand, silt, and gravel (predominantly Quaternary outwash and alluvial sediments) are also present at the Falls.

The Upper Jeffersonville (*Paraspirifer acuminatus* zone) and Silver Creek Member are exposed only along the bluff overlooking the Ohio River downstream from the mouth of Cane Run Creek. Because of limited accessibility, the Cane Run exposures will not be visited.

The Louisville Limestone is exposed at the Falls of the Ohio only during periods of low water, usually during the summer and fall. Generally, the Louisville is best exposed along the northwestern margin of the North Flats (see Fig. 2). In the fall of 1988, the upper foot of the Louisville was well exposed in the river bed

downstream from the mouth of Cane Run Creek. Fossils common in the Louisville at the Falls of the Ohio include chain corals (*Halysites*, *Cystihalysites*, and *Quepora*), tabulate corals (*Heliolites*), and small mound-shaped stromatoporoids.

The coral zone of the Jeffersonville Limestone (9.9 feet thick) unconformably overlies the Louisville Limestone at the Falls. Coral zone faunas are dominated by abundant and diverse solitary and colonial corals and mat- and mound-shaped stromatoporoids (App. A: Plates 2-4).

Numerous workers have termed the fossil beds in the Jeffersonville at the Falls of the Ohio a fossil coral reef (e.g., Conkin and Conkin, 1980). However, no organically bound, wave-resistant, topographically significant composite fossil structure has been reported in the bedrock at the Falls, or anywhere else in Jeffersonville exposures. (A few small bioherms, predominantly *Emmonsia* coral colonies, up to 10 feet in diameter and from 4 to 5 feet in height, are present at the Falls and in quarries to the north.) Sediment binding, with consequent biostrome formation, was accomplished to some degree by mat-shaped stromatoporoids, but no wave-resistant structures resulted. Coral zone communities are more accurately described as representing coral-stromatoporoid level-bottom fossil communities.

Solitary corals are most abundant in the upper part of the coral zone at the Falls. In the North Flats and Lower South Flats (Fig. 2), the upper coral zone is a dark, carbonaceous rudstone (App. A: Plate 2 [Fig. 1]) with many large rugose corals. Among these is *Siphonophrentis elongata* (also called *S. gigantea*), which attains lengths of 4 feet (Perkins, 1963). Many of the larger rugosans in the Jeffersonville assumed a curved growth habit. We presume the coral attached itself to an object such as a shell or another coral as a juvenile, and later toppled over when it had outgrown its base. The animal was then forced to grow upward, forming a curved corallum (Thompson, 1982).

The *Amphipora ramosa* zone contains abundant small, branching stromatoporoids (*Amphipora*), mat-shaped stromatoporoids, mound-shaped and branching colonial corals, and rugose corals. The *Amphipora ramosa* zone is best exposed in the Lower Ledge in the northern fossil beds and in the Upper South Flats and Islands areas in the southern fossil beds (Fig. 2). Solution cavities have developed in the Islands area of the Lower South Flats, and silicified corals and stromatoporoids stand in relief on the walls (Fig. 7).

The *Brevispirifer gregarius* zone (4.5 feet thick) contains very abundant *Brevispirifer*, large snails (*Turbonopsis shumardi*), colonial corals (*Favosites*, *Prismatophyl-*

lum), solitary corals (*Zaphrentis*, *Heterophrentis*), charophyte oogonia, and crinoid debris.

Hundreds of large *Turbonopsis* snails are preserved in the *Brevispirifer* zone; specimens are abundant in the silicified Orange Beds at the southern Falls (Fig. 2). Often, silicified specimens are preserved as internal molds encrusted by quartz. Other specimens of *Turbonopsis* are found encrusted by stromatoporoids (App. A: Plate 7 [Figs. 2A-B]); usually, the entire upper surface of the snail shell was covered, but the aperture of the shell was not. This association apparently occurred while the snail was living, and perhaps offered protective camouflage for the gastropod.

The uppermost Jeffersonville zone we will see at the main body of the Falls of the Ohio is the fenestrate bryozoan-brachiopod zone (6.3 feet thick). The unit is best exposed in the wooded area of the Upper Ledge (Fig. 2). Layers of white chert mark the base of the unit. Predominant faunal elements include pelmatozoans, fenestrate bryozoans, and brachiopods (mostly *Atrypa*, spiriferids, and strophomenids). Large colonies of the rugose coral *Eridophyllum* are present in this unit. Such colonies are asymmetrical, and individual corallites tend to lean to the south. The predominant current or wave direction during Jeffersonville deposition is presumed to be from south to north (Perkins, 1963). The south-facing corallites were better oriented to catch prey brought in by tides from the open seas to the south. Fenestrate bryozoan-brachiopod zone rocks grade northward into the laminated, mudcracked dolostones of the Vernon Fork Member, indicating that tidal flats and possibly even sabkhas were several tens of miles to the north. More open-marine conditions probably prevailed south and west of the Falls.

Overlying the bedrock in the Falls area is some 50 feet of unconsolidated sand, silt, and gravel. These sediments are principally glacial outwash and alluvial deposits (Powell, 1970; Kepferle, 1974). Large erratics, some up to 5 feet across, are found at the Falls of the Ohio (Fig. 13). Several sand and gravel pits operate in the area, and numerous bones of Pleistocene vertebrates, including mammoths, have been unearthed in such pits (Fig. 14).

Mile

- 0.00 Leave parking lot at Falls and turn left onto Winbourne Avenue and cross floodwall.
- 0.20 Stop sign. Turn left onto Sherwood Avenue.
- 0.38 Stop sign. Continue straight on Sherwood Avenue.
- 0.50 Stop sign. Turn left on Clark Boulevard.
- 0.85 Stop sign. Stansifer Avenue. Continue straight on Clark Boulevard.



Figure 13. Large sandstone erratic at the Falls of the Ohio. White scale is 5.75 inches in height.

- 1.00 Stop sign. Turn left onto Harrison Avenue.
- 1.10 Stop sign. Park Avenue. Continue straight on Harrison Avenue.
- 1.30 Stop sign. Agnew Street. Continue straight on Harrison Avenue.
- 1.80 Clark Park; parking lot on left (Stop 2).

Stop 2

Section exposed along the north bank of the Ohio River at Clark Park, Clarksville, Clark County, Indiana. New Albany Quadrangle. Clark Military Grant Section 8.

Stop Description

This outcrop exposes the upper foot of the Jeffersonville Limestone (*Paraspirifer acuminatus* zone), a complete section of the Silver Creek (15 feet thick) and Beechwood (approximately 5 feet thick) Members of the North Vernon Limestone, and a thin New Albany Shale section. The Silver Creek Member is mostly a dolomitic lime mudstone here, although packstone layers with abundant chonetid brachiopods (App. A: Plate 12 [Fig. 1]) are present. Other fossils include the spiriferid

Spinocyrtia (*Platyrachella*) (App. A: Plate 11 [Figs. 1A–B]) and trilobite fragments. Chert is common in the upper 5 feet of the unit.

The Beechwood Member is a pelmatozoan packstone or grainstone here, with many specimens of the three-spiked crinoid columnal commonly ascribed to the genus *Dolatocrinus* (Fig. 15). A prominent sandy lag zone with abundant phosphatic debris and fish bones marks the base of the Beechwood.

Mile

- 0.00 Leave parking lot at Clark Park, turn right onto Harrison Avenue.
- 0.47 Stop sign. Agnew Street. Continue straight on Harrison Avenue.
- 0.67 Stop sign. Park Avenue. Continue straight on Harrison Avenue.
- 0.80 Stop sign. Clark Boulevard. Continue straight on Harrison Avenue.
- 0.90 Stop sign. Elm Street. Continue straight on Harrison Avenue.
- 1.15 Stop sign. Turn right onto Sunset Street.
- 1.20 Stop sign. Norwood Street. Continue straight on Sunset Street.

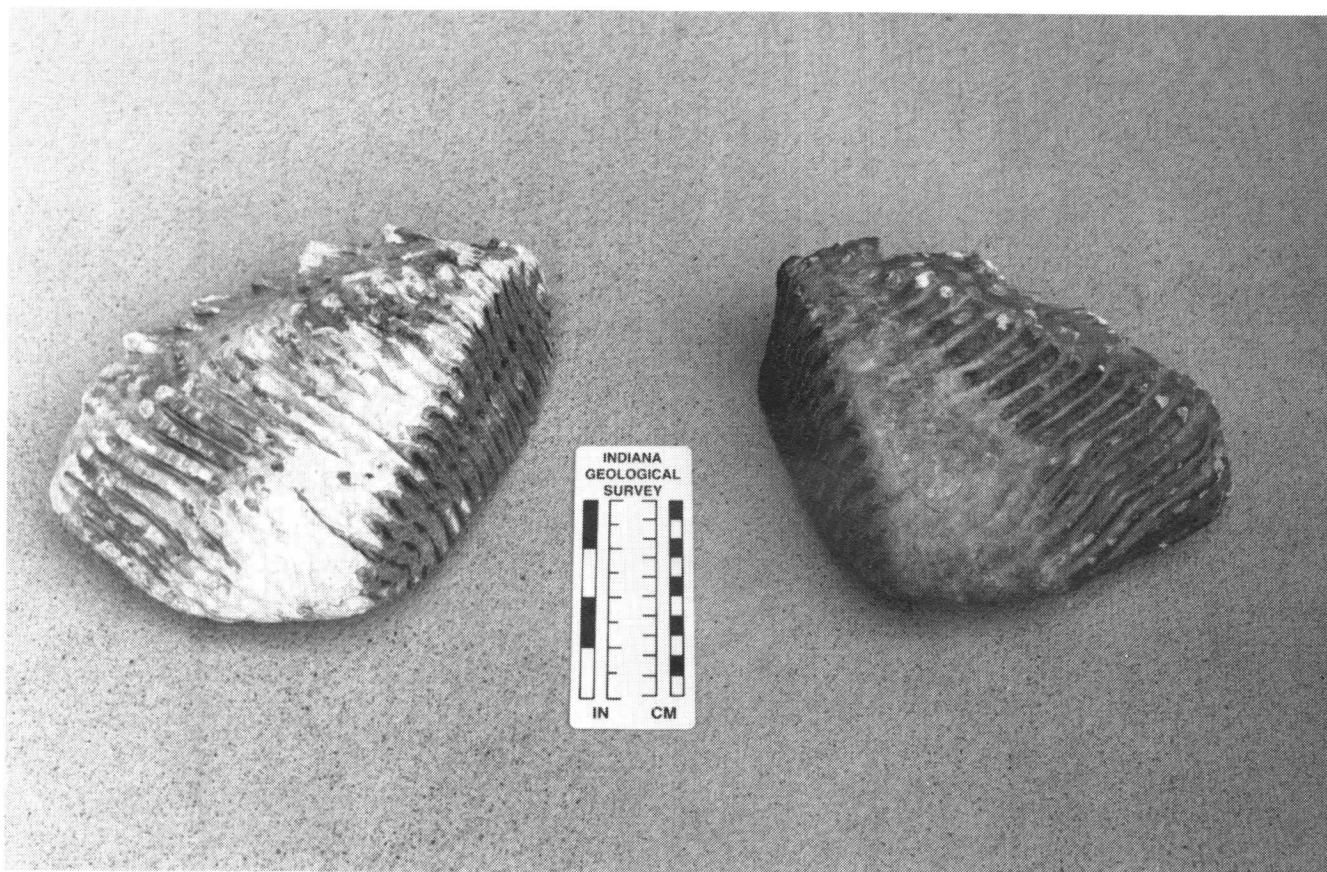


Figure 14. Mammoth teeth unearthed from Pleistocene deposits by quarrymen in Utica, Indiana.

- 1.30 Stop sign. Turn left onto Stansifer Avenue.
- 1.50 Turn left onto northbound Interstate Highway 65.
- 1.75 Veer right onto Indiana Highway 62 westbound to New Albany.
- 2.45 Stop sign. Continue straight on Indiana Highway 62.
- 4.25 Enter Floyd County.
- 4.85 Stoplight. Silver Street. Continue straight on Indiana Highway 62.
- 5.35 Stoplight. Turn left onto Vincennes Street.
- 5.60 Turn left, cross railroad tracks.
- 5.75 Turn right onto East 18th Street.
- 5.95 Pass through floodwall gate. Veer right.
- 6.25 Park under K & IT Railroad Bridge and walk to outcrops below (Stop 3).

Stop 3

Section exposed along the north bank of the Ohio River, extending from the K & IT Railroad Bridge 3,500 feet east to the mouth of Silver Creek. Southeastern edge of New Albany, Floyd County, Indiana. New Albany Quadrangle. Clark Military Grant Section 28. Note: This is the type section of the New Albany Shale.

Stop Description

When the New Albany Shale was initially described by Borden (1874), nearly 104 feet was exposed here along the Ohio River and in adjacent parts of Silver Creek. This section was apparently nearly complete, but at present most of it is covered, and only 23 feet of the Blocher Member remains exposed at and just above river level (*see* Appendix B, Stop 3). The present exposure is relatively unremarkable except for very prominent, nearly east-west-oriented joints and a subordinate system of north-south-oriented joints (Fig. 16). On a smaller scale, the shales are broken up by small polygonal fracture sets (Fig. 17) locally filled with secondary minerals. Although they have the size and appearance of mud cracks, shale radiography indicates that these features are reopened syneresis joints (Harvey and others, 1978).

Unlike other parts of the New Albany Shale, the Blocher Member (Campbell, 1946; Lineback, 1968) is largely Middle Devonian in age and is composed largely of calcareous or dolomitic black shales; many of these shales are massive and not very fissile. Total organic carbon content in these beds generally ranges from 5 to 10 percent, but in the more fissile black shales in the up-

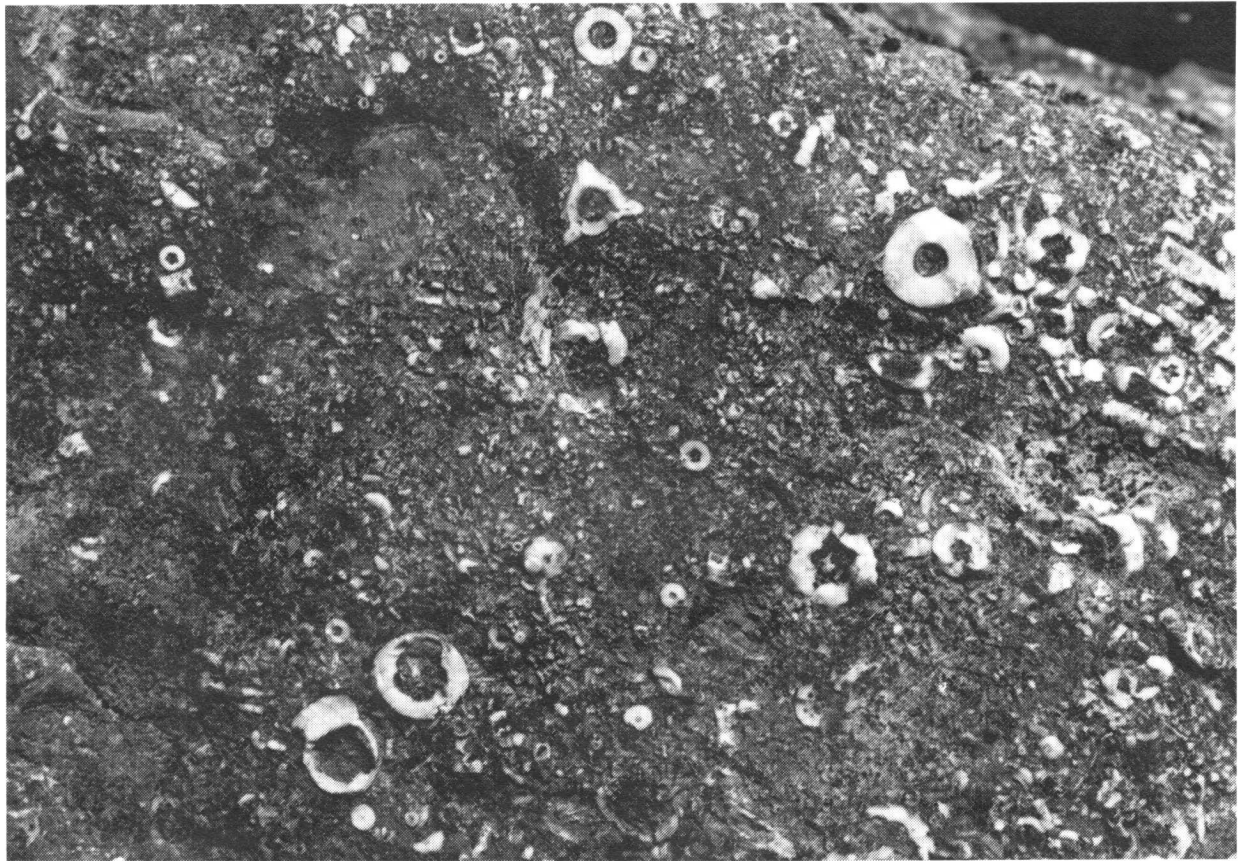


Figure 15. Crinoidal packstone of the Beechwood Member of the North Vernon Limestone (X 1). The distinctive, three-spiked crinoid columnal is usually called *Dolatocrinus*.

per part of the unit (Trousdale Formation of Campbell, 1946), total organic carbon content may approach 15 percent (Robl and Barron, 1988).

Thin beds of dolostone, gray mudstone, calcareous sandstone and siltstone, and limestone are also present locally, and some of the sandstones and siltstones exhibit flaser bedding, micro cross-laminae, and interference ripples. Burrowing is also present in some of the black shales, dolostones, mudstones, siltstones, and sandstones, and a low-diversity, high-abundance fauna of brachiopods and cricoconarids is present locally in some of the black shales. The unit is everywhere bound above and below by sandy pyritic lag or condensation horizons, although similar horizons may be present within the unit. Figure 18 indicates that the Blocher thickens toward the west and northwest and apparently pinches out on the Cincinnati Arch from Casey County southward, but it locally intertongues with the Duffin facies of the equivalent Portwood Member in east-central Kentucky (Campbell, 1946; Etensohn and Geller, 1986; Etensohn and others, 1989).

At this stop, lag horizons are exposed at neither the base nor the top of the Blocher, but partially pyritized

siltstone layers at approximately 2, 5, and 9 feet above present river level are similar (Fig. 17). Some of these horizons exhibit well-developed interference ripples (Fig. 20). Pyritized burrows and lingulid brachiopods are abundant in some of the less fissile, "crumbly" black shale layers (Fig. 21; App. A: Plate 13 [Fig. 4]). Thin, calcareous siltstone layers with flaser beds and micro cross-laminae are nearly everywhere common on close inspection.

Optional Stop A

Section exposed along the north bank of the Ohio River, approximately 800 feet downstream (west) of the mouth of Silver Creek. This stop can be reached by walking 0.5 mile east along the Ohio River from Stop 3.

Stop Description

This stop will be visited only if time permits. Keferle (1974) reported "partially carbonized plant remains in gray sandy silt at water level," which yielded radiocarbon dates of $2,840 \pm 250$ years along the north bank of the Ohio River some 800 feet west of the mouth of Silver Creek. These deposits probably represent sed-



Figure 16. Prominent joints in the New Albany Shale at Stop 3.

iments deposited during periods of high water along the Ohio River or possibly along a meander of Silver Creek, which has since been cut off.

Mile

- 0.00 Travel east along floodwall, back to intersection with East 18th Street.
- 0.25 Turn left onto East 18th Street, pass through floodwall gate.
- 0.45 Stop sign. Turn left onto East Main Street.
- 0.60 Stop sign. Continue straight on East Main Street.
- 1.68 Stoplight. Pearl Street. Continue straight on East Main Street.
- 1.70 Stoplight. Turn right onto State Street.
- 1.80 Stoplight. Market Street. Continue straight on State Street.
- 1.90 Stoplight. Turn left onto Spring Street.
- 2.00 Stoplight. Continue straight on Spring Street.
- 2.10 Take ramp to Interstate Highway 64 westbound.
- 3.80 Take exit 121 to Interstate Highway 265 eastbound.
- 6.90 Grant Line Road overpass.
- 9.10 Cross Jacobs Creek.
- 9.90 Cross Silver Creek, enter Clark County, Indiana.
- 10.60 Exit to Interstate Highway 65 northbound.

- 28.10 Rest stop.
- 29.80 Enter Scott County, Indiana.
- 41.90 Enter Jackson County, Indiana.
- 52.60 Cross Vernon Fork of the Muscatatuck River.
- 56.30 Leave Interstate Highway 65 by taking exit 50A (U.S. Highway 50 eastbound).
- 57.00 Stoplight. U.S. Highway 31. Continue straight on U.S. Highway 50.
- 59.30 Muscatatuck Regional Wildlife Refuge on right.
- 59.40 Enter Jennings County, Indiana.
- 63.70 Entrance road to Berry Materials' Hayden Quarry (Stop 5), which we will visit after the next stop. Continue straight on U.S. Highway 50.
- 69.90 Stoplight. Walnut Street, North Vernon, Indiana. Veer left on U.S. Highway 50.
- 70.20 Junction of U.S. Highway 50 with Indiana Highway 3 and Indiana Highway 7. Continue straight on U.S. Highway 50.
- 70.35 Stoplight. Jackson Street. Continue straight on U.S. Highway 50.
- 70.45 Stoplight. Veer left, cross railroad tracks.
- 70.50 Cross railroad tracks.
- 70.75 Berry Materials North Vernon Quarry (Stop 4).

Stop 4

Berry Materials Quarry, North Vernon, Jennings County, Indiana. Butlerville Quadrangle. Section 27, T. 7 N, R. 8 E. Note: This is the principal reference section of both the Vernon Fork Member of the Jeffersonville Limestone and the Selmier Member of the New Albany Shale.

Stop Description

This quarry exposes a complete section from the Laurel Member of the Salamonie Dolomite upward to the base of the Morgan Trail Member of the New Albany Shale. We will be concerned with the Jeffersonville, North Vernon, and New Albany strata only.

The Geneva Dolomite Member (27.5 feet thick) of the Jeffersonville Limestone unconformably overlies the Louisville Limestone (5.5 feet thick) in this quarry. Although one layer approximately 2 feet from the top of the unit is considerably lighter brown in color, the Geneva is predominantly a chocolate-brown, vuggy, porous dolostone with locally abundant fossil molds. Fossils include solitary and colonial corals, stromatoporoids, and the rostroconch *Hippocardia*. *Amphipora* molds are abundant in the upper 2 feet of the Geneva, suggesting a facies relationship with the overlying *Amphipora ramosa* zone beds measured by Droste (Droste and Shaver, 1975). Chert nodules, beds, and stringers are present in the upper two-thirds of the unit.

The *Amphipora ramosa* zone (6 feet thick) is not easily accessible in this quarry, as it lies at the top of the second bench, some 25 to 30 feet above the quarry floor. The *Amphipora ramosa* zone is a light- to medium-brownish-gray, dolomitic limestone with abundant fossils, including branching and solitary corals and, of course, *Amphipora*.

Overlying the *Amphipora ramosa* zone, the Vernon Fork Member of the Jeffersonville Limestone (16.9 feet thick) is well exposed on the third bench of the quarry. Vernon Fork lithologies include thin- to thick-laminated, mudcracked, unfossiliferous dolostones (Fig. 9), bioturbated dolomicrites, and dolomicrite beds containing calcite pseudomorphs after gypsum (arrowhead or fishtail twins) (see Fig. 10). A typical Vernon Fork cycle begins with a burrowed, sub- to intertidal dolomicrite, which grades upward into thickly laminated dolomicrite, and finally into high intertidal or supratidal, thinly laminated dolomicrite with deep mud cracks. The upper contact of the Vernon Fork Member with the *Paraspirifer acuminatus* zone is marked by a sandy horizon with fish bone fragments.

The *Paraspirifer acuminatus* zone (5.75 feet thick) overlies the Vernon Fork Member in this quarry. The unit is an abundantly fossiliferous lime packstone to grainstone; crinoid debris, brachiopods, and bryozoans are the commonest fossils. Chert is abundant in the form of large nodules up to more than a foot across. Some *Paraspirifer* specimens found here are unusually small when compared to those found at the Falls of the Ohio or at Scottsburg. Although environmental factors may have been responsible for this phenomenon, this is not certain.

The Speed Member (2.6 feet thick) of the North Vernon Limestone unconformably overlies the Jeffersonville Limestone at this stop. The Speed is an abundantly fossiliferous, medium-gray, stylolitic limestone (packstone) with abundant pelmatozoan debris, bryozoans, and brachiopods.

Unconformably overlying the Speed, the Beechwood Member (4.0 feet thick) is a light-gray, fossiliferous, carbonate grainstone with abundant pelmatozoan debris, brachiopods, and bryozoans. The base of the Beechwood is marked by a prominent sandy lag zone

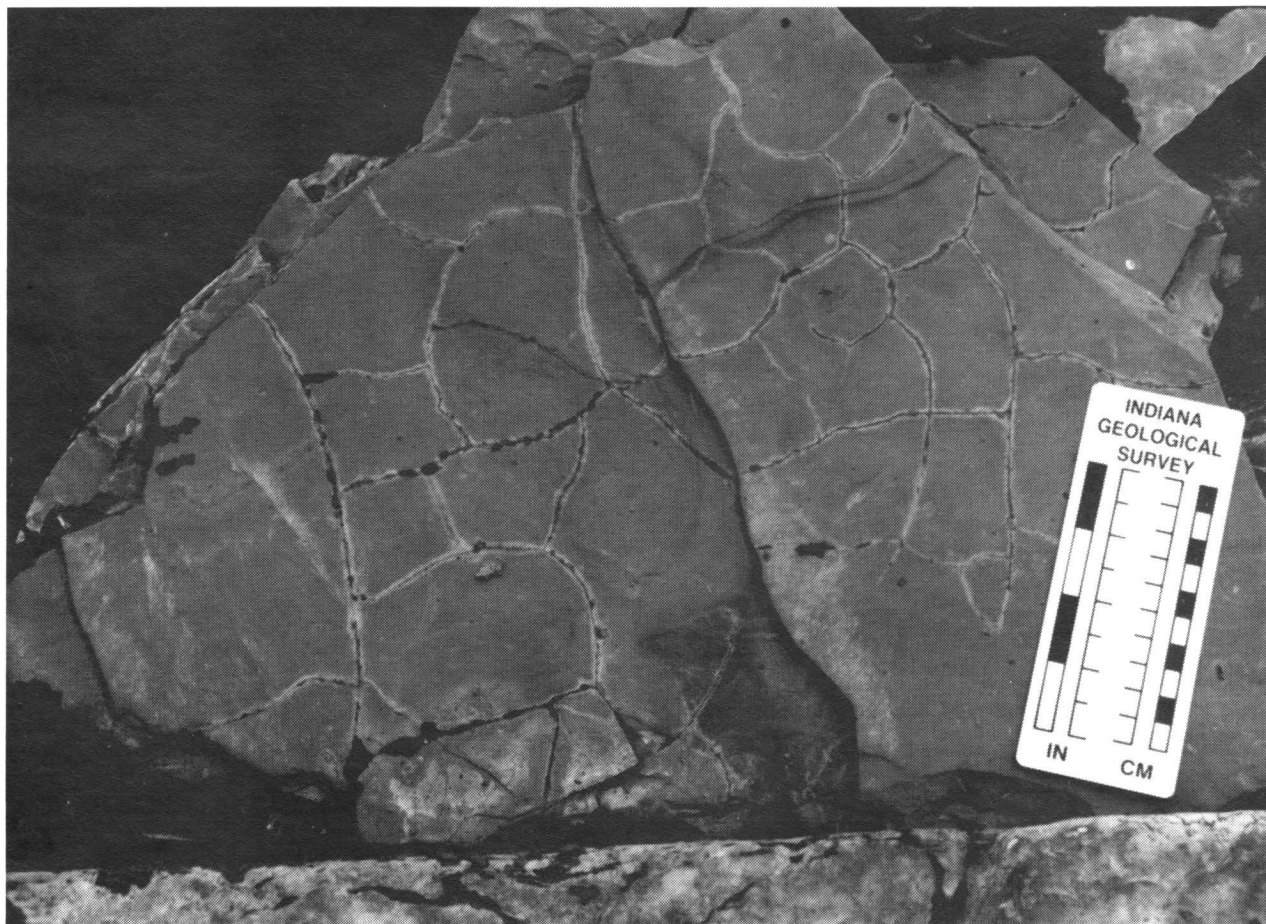


Figure 17. Syneresis joints in the Blocher Member of the New Albany (Stop 3).

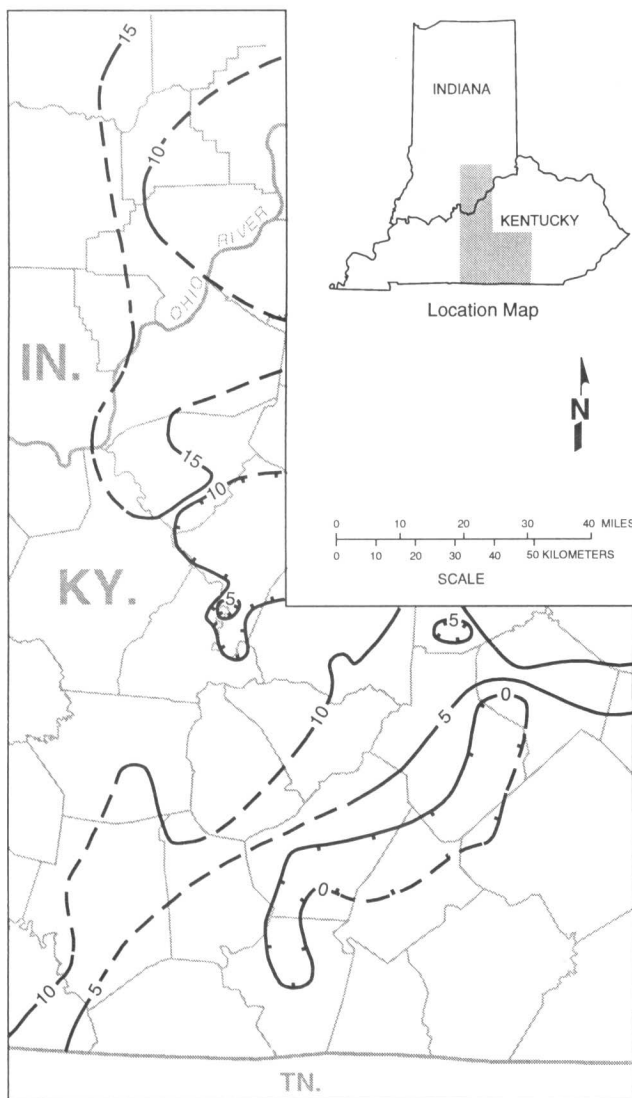


Figure 18. Isopach map of the Blocher Member of the New Albany Shale in west-central Kentucky and adjacent parts of Indiana. Modified from Geller (1985).

with abundant phosphatic nodules, quartz sand, and fish bone fragments.

Only the Blocher, Selmier, and lower Morgan Trail Members of the New Albany Shale are exposed in this quarry. The lower part of the section in Figure 11 was measured here.

The Blocher Member of the New Albany Shale disconformably overlies the North Vernon Limestone. The disconformity is marked by a basal lag horizon or bone bed containing detrital quartz, pyrite, phosphatic nodules, and phosphatic fossil debris, which fills small depressions atop the underlying limestone.

The Blocher Member here is approximately 11 feet thick and consists largely of black, dolomitic shale. Dolostone beds and carbonate concretions are present lo-

cally in this unit. Near the base of the Blocher, black shale layers with abundant benthic fossils are present. Most abundant is the rhynchonellid brachiopod "*Leiorhynchus*," an unidentified chonetid brachiopod, and an unidentified cricoconarid. Fossiliferous layers generally contain only one type of fossil, but that fossil is generally very abundant. In the case of the rhynchonellid, individuals are found in patches, with many individuals stacked on top of each other (App. A: Plate 13 [Fig. 2]). Such stacks were probably developed on dead individuals and may have formed small "islands" on the sea bottom that elevated live brachiopods above foul bottom muds. Such low-diversity, high-abundance communities are typical of somewhat restricted, stressful environments. Factors such as foul, muddy bottoms or reduced oxygen content may have been the restricting elements in Blocher environments.

A pyritic lag zone separates the Blocher Member from the overlying Selmier Member. The Selmier is approximately 22 feet thick and consists largely of greenish-gray to olive-gray shale with minor siltstone and dolostone layers; carbonate concretions are present near the middle and upper parts of the unit. Campbell (1946), Lineback (1970), and Hasenmueller and others (1983a) reported burrows, lingulid brachiopods, *Callixylon* logs, pelecypods, gastropods, and the supposed crustacean *Spathiocaris* in the Selmier. These faunas suggest a less restricted, more open-marine environment than that interpreted for the Blocher. (Although *Spathiocaris* has historically been considered a crustacean, Rolfe (1969) indicated that *Spathiocaris* was more likely an ammonoid anaptacus and should be synonymized with the genus *Sidites*.)

The overlying Morgan Trail Member is separated from the Selmier by a very thin pyritic lag zone. The unit is composed almost entirely of fissile black shale, although pyritic and silty carbonate laminae are present. Only about 3 feet of Morgan Trail is exposed here, although the unit attains thicknesses of up to 40 feet in the subsurface (Hasenmueller and others, 1983a).

Mile

- 0.00 Leave North Vernon Quarry.
- 0.25 Cross railroad tracks.
- 0.30 Cross railroad tracks. Stoplight. Veer right onto U.S. Highway 50.
- 0.40 Stoplight. Jackson Street. Continue straight on U.S. Highway 50.
- 0.55 Stoplight. Junction of U.S. Highway 50 with Indiana Highway 3 and Indiana Highway 7. Continue straight on U.S. Highway 50.
- 0.85 Stoplight. Walnut Street. Veer right, continue west on U.S. Highway 50.
- 6.55 Turn right onto entrance road to Hayden Quarry.

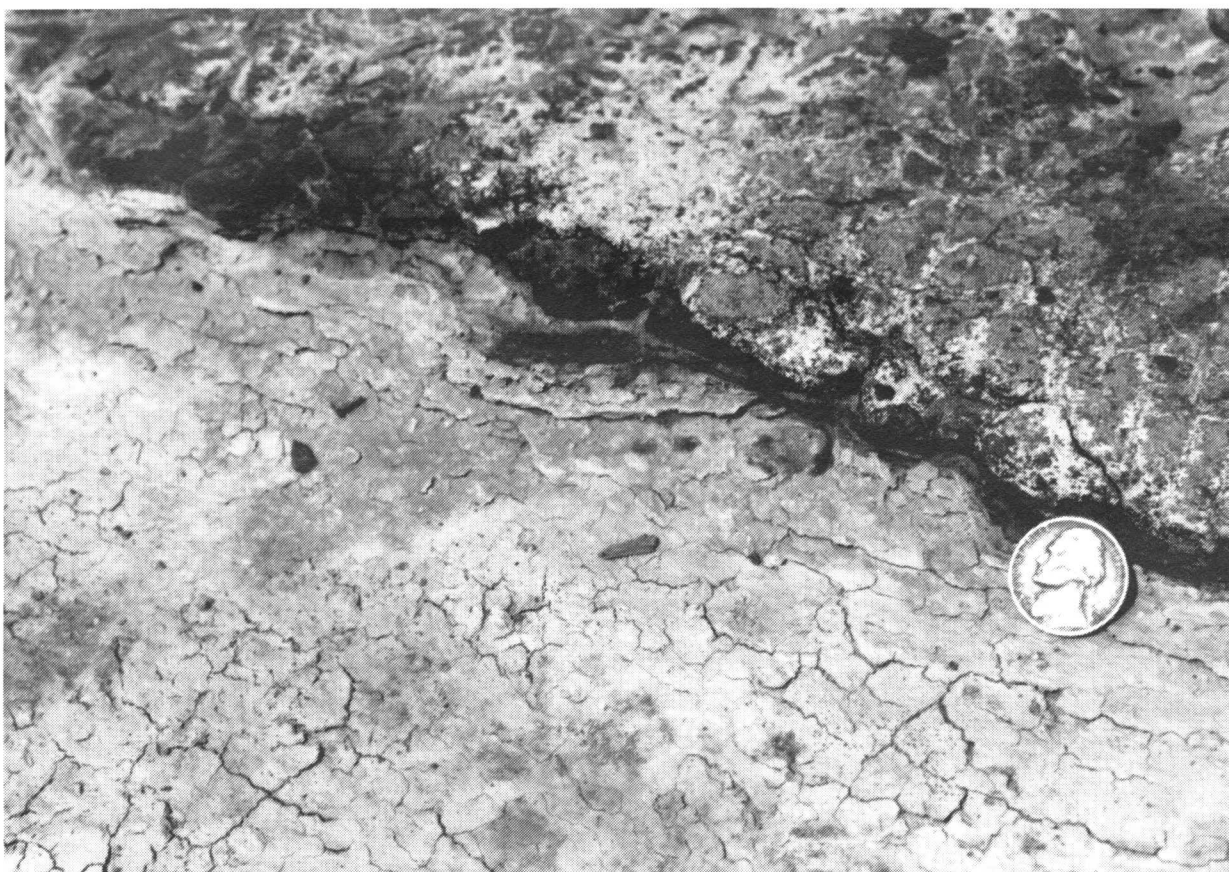


Figure 19. Weathered marcasitic lag zone in the Blocher Member of the New Albany Shale (Stop 3).

6.70 Cross railroad tracks.

7.05 Berry Materials' Hayden Quarry (Stop 5).

Stop 5

Berry Materials' Quarry, Hayden, Jennings County, Indiana. Hayden Quadrangle. SE 1/4, SE 1/4, Section 3, T. 6 N., R. 7 E.

Stop Description

A complete section of the Jeffersonville and North Vernon Limestones is exposed at this stop. Lithologies are similar to those in the North Vernon Quarry, but are not as easily accessible. Only the Geneva Dolomite Member (19 to 22 feet thick) of the Jeffersonville Limestone was measured because of the lack of safely measurable outcrops higher in the section. Ault (1990) reported 22 feet of the Geneva Dolomite Member, 30.6 feet of the upper Jeffersonville Limestone (including the *Amphipora ramosa* zone, the Vernon Fork Member, and the *Paraspirifer acuminatus* zone), and 6.1 feet of North Vernon Limestone in this quarry.

This stop would be relatively unremarkable were it not for two factors. First, the upper surface of the Geneva Dolomite Member of the Jeffersonville Limestone

exhibits large mounds, some as much as 10 feet high and over 100 feet in length (Fig. 22). When viewed in cross section, the beds within a mound can be seen dipping away from the mound's axis. The origin of these features is not clear until the lowest pit in the quarry is visited. The unconformity at the base of the Geneva exhibits considerable relief, and the Geneva is draped over topographic highs developed on the underlying Silurian dolostones.

The second interesting feature in this quarry is the presence of large brecciated masses in the upper 30 feet of the Jeffersonville Limestone, North Vernon Limestone, and possibly the New Albany Shale (Fig. 23). These features probably represent paleokarst horizons, but the precise timing of their formation is unknown.

Saturday Morning, September 11, 1993

Mile

- 0.00 Leave Day's Inn parking lot. Turn right (west) onto Jefferson Street. Stoplight (First Street) ahead. Continue straight on Jefferson Street.
- 0.10 Stoplight. Turn right onto Second Street.

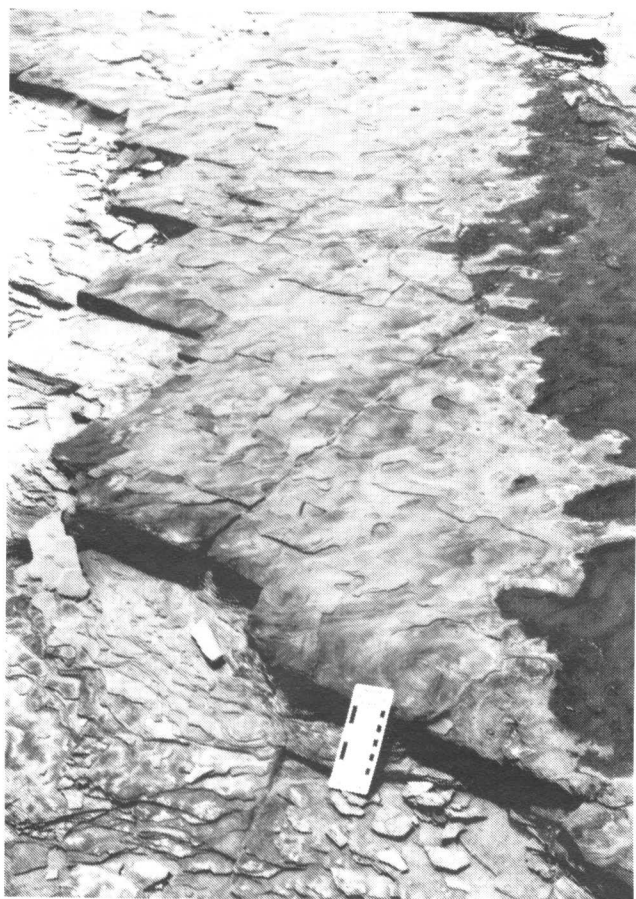


Figure 20. Interference ripples in siltstone layers in the Blocher Member of the New Albany Shale (Stop 3).

- 0.20 Stoplight. Market Street. Continue straight on Second Street.
- 0.30 Stoplight. Main Street. Continue straight on Second Street, cross Clark Bridge over Ohio River.
- 0.60 Fountain in Ohio River at left.
- 1.40 Jeffersonville exit. Exit right at end of bridge, then turn right onto Court Avenue at end of ramp.
- 1.90 Stoplight. Pearl Street. Continue straight on Court Avenue.
- 1.95 Stoplight. Turn left onto Spring Street.
- 2.20 Stoplight. Eighth Street. Continue straight on Spring Street.
- 2.38 Stoplight. Tenth Street. Continue straight on Spring Street.
- 2.56 Stoplight. Twelfth Street. Continue straight on Spring Street.
- 2.72 Stoplight. Wall Street. Continue straight on Spring Street.
- 3.15 Stoplight. Eastern Boulevard. Continue straight on Spring Street.
- 3.60 Stop sign. Dutch Lane. Spring Street is called Hamburg Pike north of Jeffersonville. Continue straight on Hamburg Pike.
- 3.95 Turn right onto Quarry Street.
- 4.42 Atkins Quarry. Scale house and office on right (Stop 6).

Stop 6

Atkins Quarry, Jeffersonville, Clark County, Indiana. Jeffersonville Quadrangle. W 1/4 of Clark Military Grant 10.

Stop Description

A complete section of Jeffersonville Limestone, lithologically similar to the Falls of the Ohio outcrops, is exposed at this stop. Overlying the Jeffersonville Limestone is some 20 feet of the Silver Creek Member of the North Vernon Limestone, which is a massive, light- to medium-bluish-gray, dolomitic limestone with abundant chert in the upper half of the unit. However, the section is essentially vertical and therefore largely inaccessible.

The primary reason for this stop is to enable participants to collect fossils. Excellent silicified specimens of the brachiopods *Atrypa* and *Spinocyrtia* (App. A: Plate 11) may be collected from eroded outcrops of Beechwood and Silver Creek present at the upper rim of the quarry. Also present are large, excellent specimens of the coral *Favosites turbinatus* and small auloporida coral colonies.

Mile

- 0.00 Leave Atkins Quarry.
- 0.50 Stop sign. Turn right onto Hamburg Pike.
- 1.85 Stop sign. Truckers Boulevard. Continue straight on Hamburg Pike.
- 2.25 Stoplight. New Albany-Charlestown Road. Continue straight on Hamburg Pike.
- 3.51 Stop sign. Coopers Lane. Continue straight on Hamburg Pike.
- 4.42 Stoplight. Railroad tracks. Turn right onto Hamburg Pike.
- 4.80 Cross Silver Creek.
- 7.05 Sellersburg city limits.
- 7.67 Stoplight. Turn right on Indiana Highway 31.
- 7.90 Stoplight. Turn right onto Utica Street.
- 8.00 Stop sign. New Albany Street. Continue straight on Utica Street.
- 8.35 Cross railroad tracks.
- 8.45 Stop sign. Cross railroad tracks.

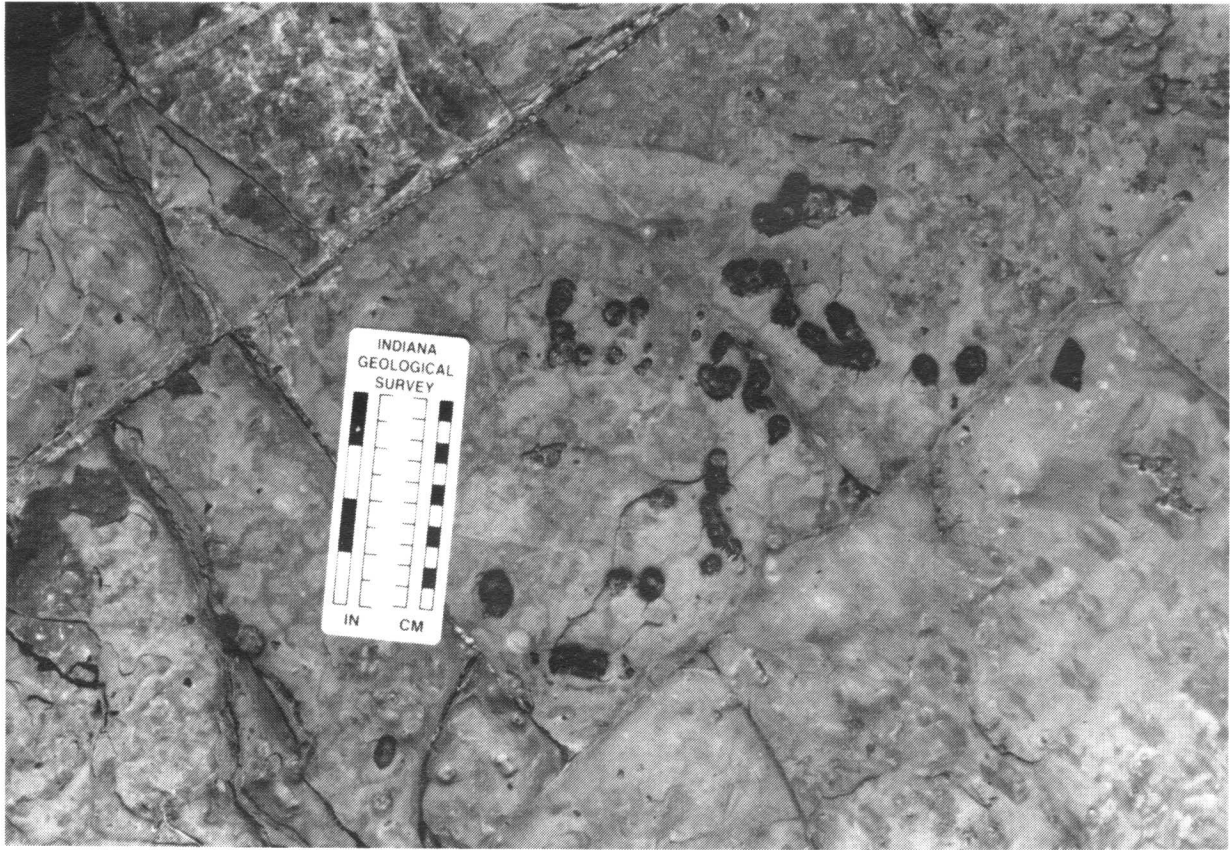


Figure 21. Pyritized burrows in the Blocher Member of the New Albany Shale (Stop 3).

8.78 Sellersburg Stone Company Quarry. Scale house and office on left (Stop 7).

Stop 7

Sellersburg Stone Company Quarry, Sellersburg, Clark County, Indiana. Charlestown Quadrangle. Center of Clark Military Grant Section 90.

Stop Description

A complete section of Jeffersonville Limestone overlies very fossiliferous Wabash carbonates in this quarry. The Jeffersonville is, in turn, overlain by the Speed, Silver Creek, and Beechwood Members of the North Vernon Limestone, which are very well exposed. Jeffersonville lithologies and faunas are typical; however, the coral zone is very thin: only 2.5 feet.

At this location, the Speed Member of the North Vernon Limestone is a medium- to dark-gray, abundantly fossiliferous limestone with many platy bryozoans and pelmatozoan fragments. The overlying Silver Creek and Beechwood Members are of typical lithologies. The residuum developed on the upper surfaces of the North Vernon units offers excellent fossil collecting; thousands of brachiopods have weathered free from the matrix.

Mile

- 0.00 Leave Sellersburg Stone Company Quarry parking lot, turn right onto East Utica Street.
- 0.37 Stop sign. Cross railroad tracks.
- 0.45 Cross railroad tracks.
- 0.82 Stop sign. New Albany Street. Continue straight on East Utica Street.
- 0.90 Stoplight. Turn left onto Indiana Highway 31 (North Indiana Avenue).
- 1.12 Stoplight. Continue straight on Indiana Highway 31.
- 1.25 Turn right onto northbound Interstate Highway 65.
- 16.80 Enter Scott County, Indiana.
- 22.30 Exit 29. Exit Interstate Highway 65 to Indiana Highway 56.
- 22.65 Stoplight. Turn right onto Indiana Highway 56.
- 23.12 Stoplight. U.S. Highway 31. Continue straight on Indiana Highway 56.
- 23.45 Stoplight. Bond Street. Continue straight on Indiana Highway 56.
- 23.60 Stoplight. Continue straight on Indiana Highway 56.



Figure 22. Mound in the Geneva Dolomite Member of the Jeffersonville Limestone. These features developed from compaction of the overlying sediments over the somewhat irregular surface of the Silurian-Devonian unconformity (Stop 5).

- 28.00 Caution lights. Indiana Highway 56 merges with Indiana Highway 3. Continue straight on Indiana Highway 56 and Indiana Highway 3.
- 29.90 Entrance to Scott County Stone Company Quarry. Turn right onto Indiana Highway 203.
- 30.05 Turn left to scale house and office (Stop 8).

Stop 8

Scott County Stone Company Quarry, at intersection of Indiana Highways 3 and 203, Scott County, Indiana. Blocher Quadrangle. NE 1/4, NW 1/4 Section 20, T. 3 N, R. 8 E.

Stop Description

The Jeffersonville and North Vernon Limestone sections in this quarry exhibit interesting lithologic variations from typical southern facies seen in the Falls area. The *Brevispirifer gregarius* zone (9.8 feet thick) is unusually cherty and argillaceous. Other notable stratigraphic variations include the absence of the Silver Creek Member of the North Vernon Limestone, and the presence of well-defined, small-scale crossbedding in the Beechwood Member. Excellent fossils may be collected

in the Jeffersonville boulders littering the floor of the quarry.

This stop concludes the field conference. If the participants wish, they may return to the Falls of the Ohio (Stop 1) with the trip leaders for additional observation of fossils and rocks exposed at this remarkable site.

ACKNOWLEDGMENTS

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Figure 23. Breccias in the Jeffersonville Limestone, probably caused by ancient or recent karst processes (Stop 5).

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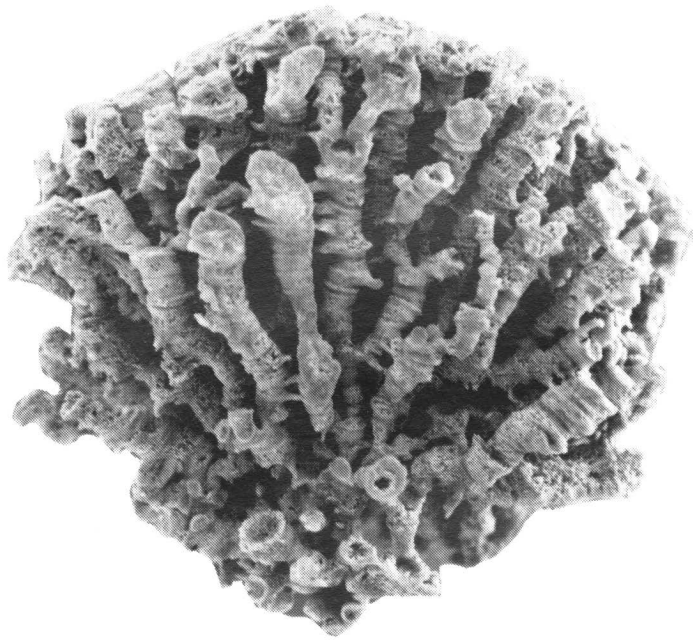
**APPENDIX A:
PLATES**

PLATE 1

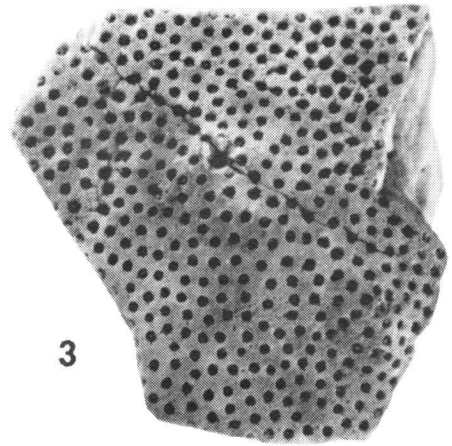
Representative fossils of the Louisville Limestone and Wabash Formation (all figures X 1 unless otherwise noted).

Figure

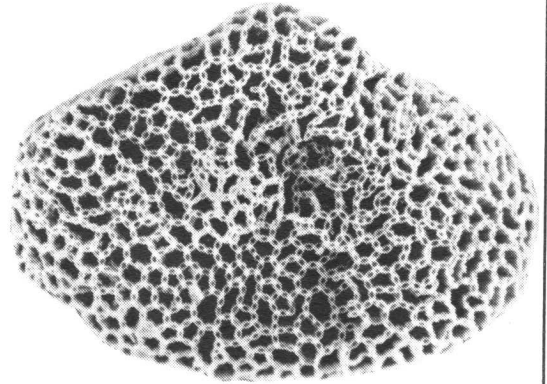
1. *Entelophyllum eruciforme*. Side view of silicified colony acidized from matrix. Riprap along floodwall. Louisville Limestone or Wabash Formation. Clarksville, Indiana.
2. *Arachnophyllum striatum*. Top view of part of a large colony. Louisville Limestone. Charlestown, Indiana.
3. *Heliolites spongiosus*. Top view of colony. Louisville Limestone. Falls of the Ohio.
4. *Quepora huronensis*. Top view of silicified colony, acidized from matrix. Differs from other common genera, *Halysites* and *Cystihalysites* (also found in the Falls of the Ohio area), in lacking mesocorallites and septal spines. Louisville Limestone. Falls of the Ohio.
5. *Astylospongia* sp. (A) Side and (B) top views. Louisville Limestone. Falls of the Ohio.



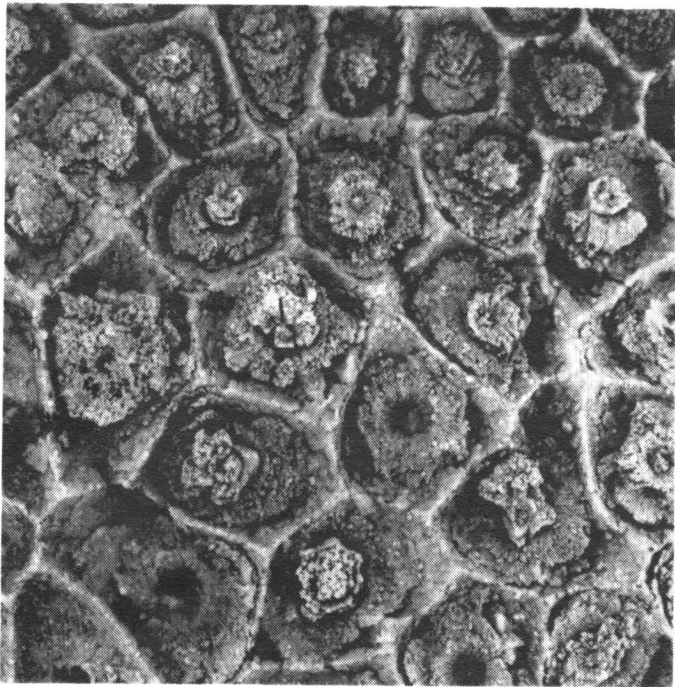
1



3



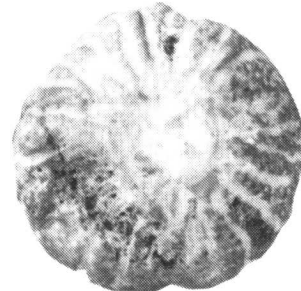
4



2



5 A



5 B

PLATE 1

PLATE 2

Representative fossils of the Jeffersonville Limestone coral zone (all figures X 1 unless otherwise noted).

Figure

1. Sawed slab of carbonaceous limestone containing various rugose and tabulate corals, including *Cystiphylloides* and *Thamnopora*. Upper part of coral zone. Jeffersonville, Indiana.
2. *Thamnopora limitaris*. In bedrock. Lower foot of coral zone, in bed of Ohio River, downstream from Cane Run Creek. Clarksville, Indiana.
3. *Siphonophrentis elongata*. Side view of large corallum (X 0.6). Specimens of this species up to 4 feet in length and 4 inches in diameter are exposed at the Falls of the Ohio. Lower foot of coral zone, Falls of the Ohio.
4. *Thamnopora limitaris*. Silicified specimen acidized from matrix. Lower foot of coral zone, in bed of Ohio River, downstream from Cane Run Creek. Clarksville, Indiana.

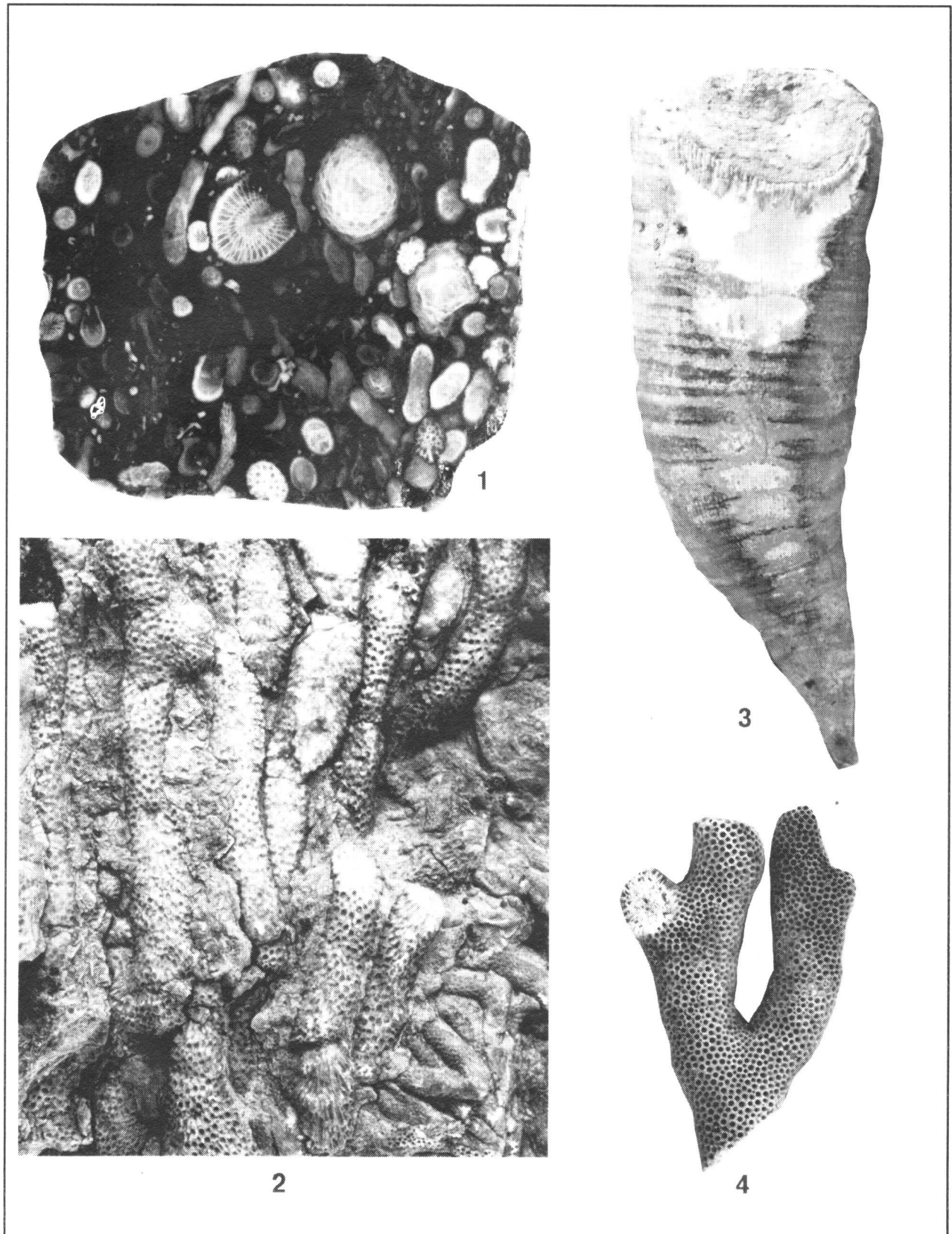


PLATE 2

PLATE 3

Representative fossils of the Jeffersonville Limestone coral zone (all figures X 1 unless otherwise noted).

Figure

1. *Aulacophyllum perlamellosum*. (A) Top and (B) side views. Lower foot of coral zone, in bed of Ohio River, downstream from Cane Run Creek. Clarksville, Indiana.
2. *Heterophrentis* sp.(?) Side view of silicified specimen. Lower foot of coral zone, in bed of Ohio River, downstream from Cane Run Creek. Clarksville, Indiana.
3. *Scenophyllum conigerum*. Side view. Lower foot of coral zone, in bed of Ohio River, downstream from Cane Run Creek. Clarksville, Indiana.
4. *Acrophyllum* sp. Side view. Lower foot of coral zone, in bed of Ohio River, downstream from Cane Run Creek. Clarksville, Indiana.

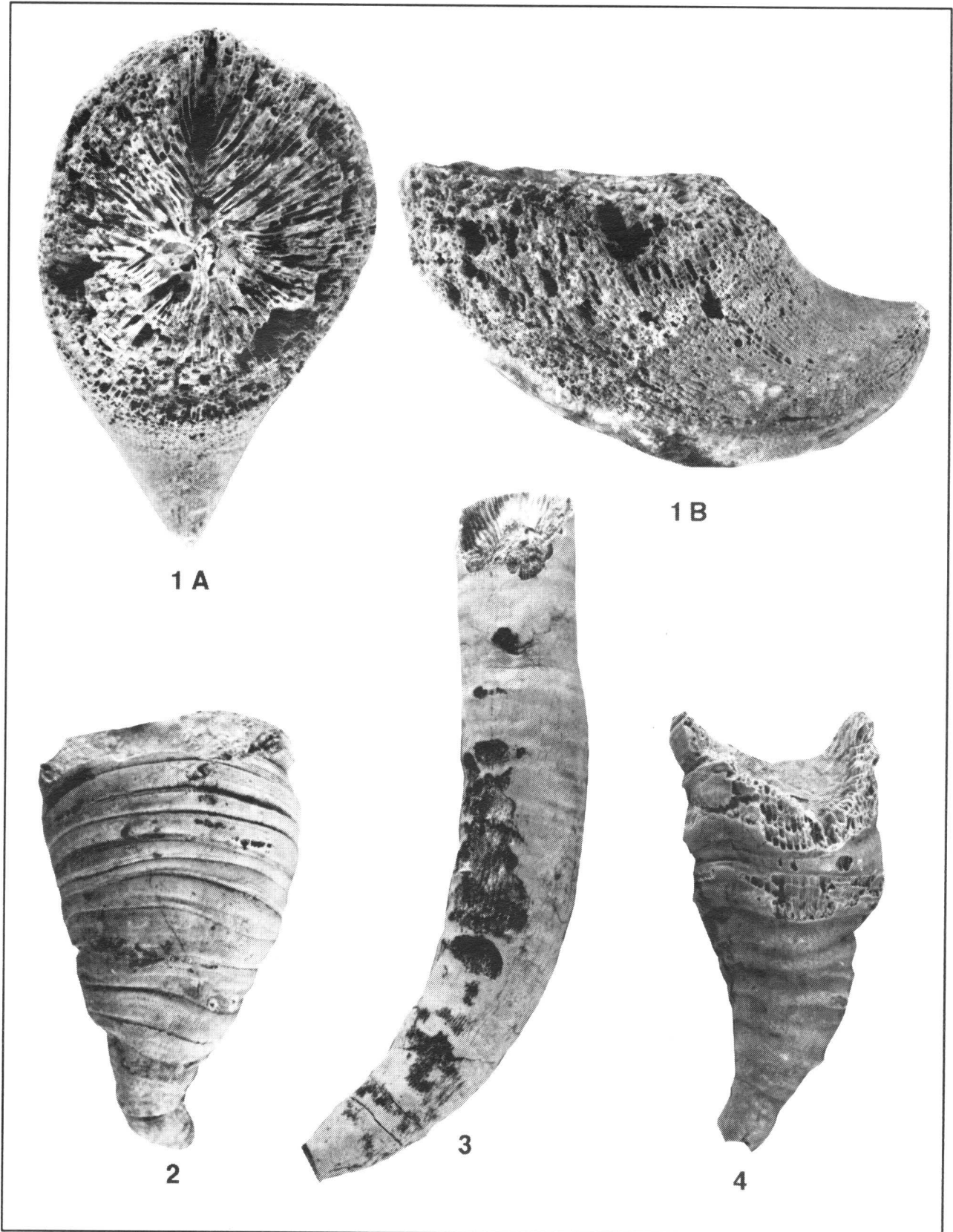


PLATE 3

PLATE 4

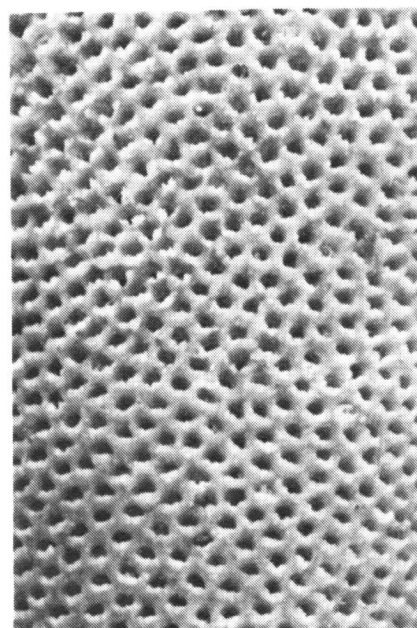
Representative fossils of the Jeffersonville Limestone coral zone.

Figure

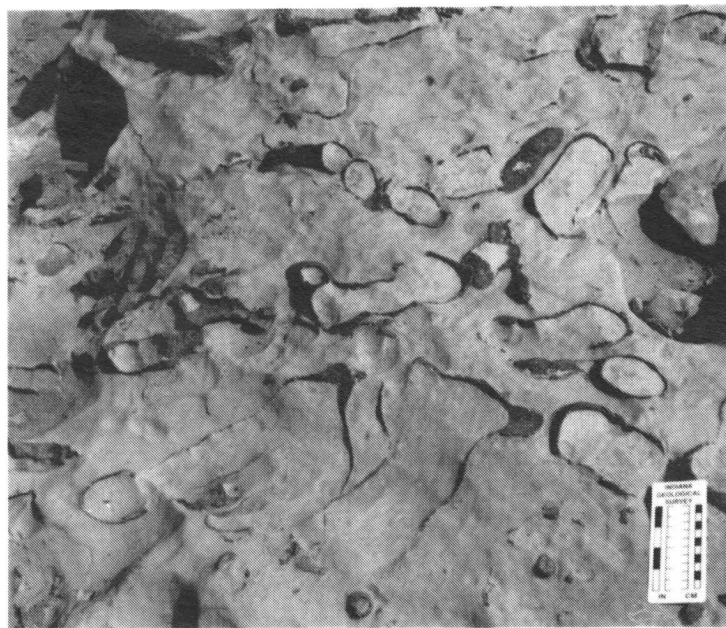
1. *Alveolites winchellana*. (A) Side view of silicified partial colony acidized from matrix (X 0.6). (B) Closeup of surface of colony (X 2.0). Lower foot of coral zone, in bed of Ohio River, downstream from Cane Run Creek. Clarksville, Indiana.
2. *Emmonsia tuberosa*. View of specimens in bedrock with silicified rinds and calcareous centers. Lower foot of coral zone. Falls of the Ohio. Scale: 5.75 inches (14.5 cm).
3. *Emmonsia emmonsi*. Fragment of broken colony showing prismatic corallites and mural pores (X 1). Upper coral zone. Scottsburg, Indiana.



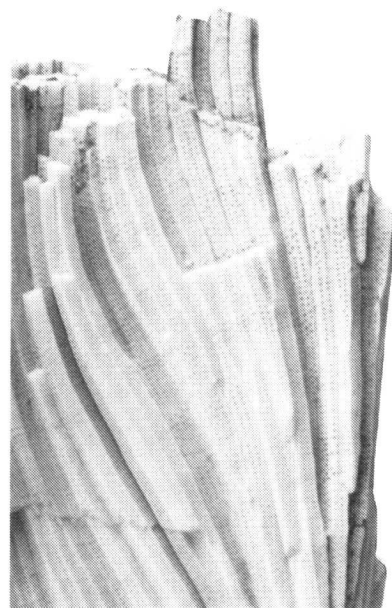
1 A



1 B



2



3

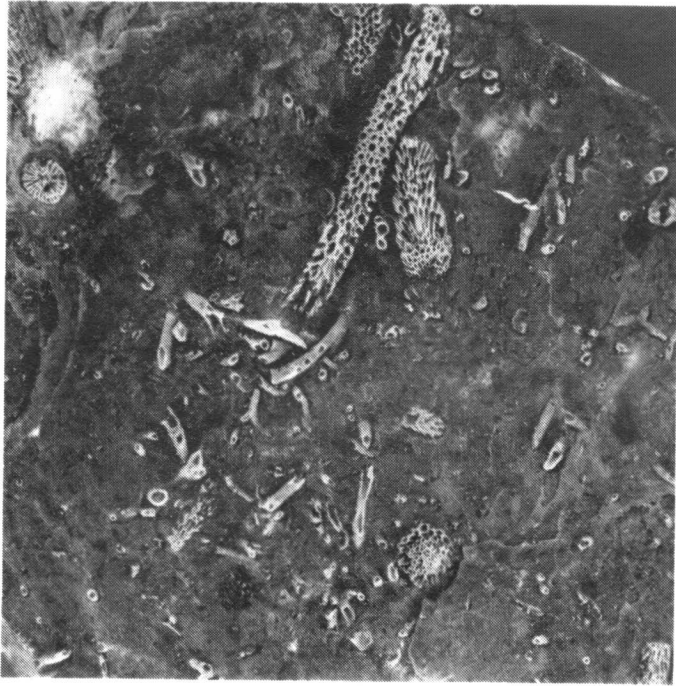
PLATE 4

PLATE 5

Representative fossils of the Jeffersonville Limestone *Amphipora ramosa* zone (all figures X 1 unless otherwise noted).

Figure

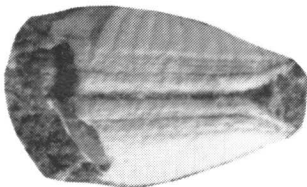
1. *Amphipora ramosa* with branching tabulates in bedrock. Falls of the Ohio.
2. Conical stromatoporoid. Although not as abundant as moundlike or matlike forms, conical stromatoporoids, some up to 1 foot in height, are common in the *Amphipora ramosa* zone. Falls of the Ohio.
3. *Hippocardia cunea*. (A) Top and (B) side views. Commonly identified as *Conocardium*, this rostroconch is present in most Jeffersonville zones. Jeffersonville, Indiana.
4. *Pleurodictyum cylindricum*. Top view of weathered colony (X 0.8). Upper *Amphipora ramosa* zone. Falls of the Ohio.



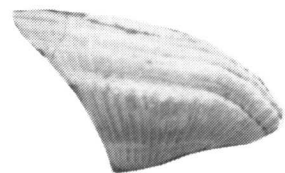
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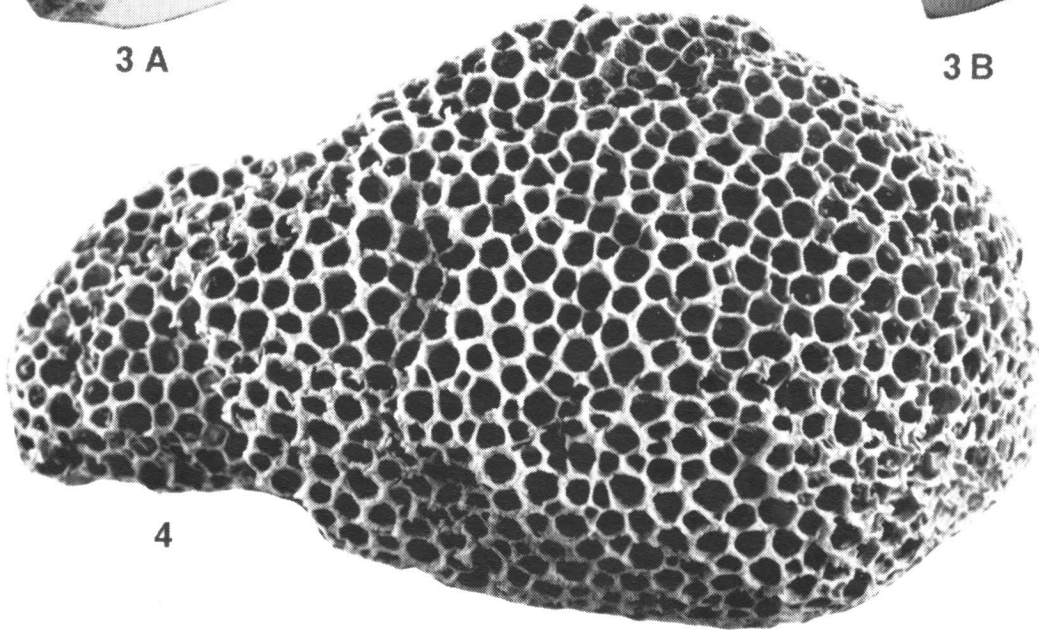
2



3 A



3 B



4

PLATE 5

PLATE 6

Representative fossils of the Jeffersonville Limestone *Brevispirifer gregarius* zone (all figures X 1 unless otherwise noted).

Figure

1. *Favosites turbinatus*. Basal view of colony showing characteristic wrinkled appearance (X 0.6). Upper foot of the *Brevispirifer gregarius* zone. Falls of the Ohio.
2. *Favosites turbinatus*. Side view of small specimen showing turbinate shape. Upper foot of the *Brevispirifer gregarius* zone. Falls of the Ohio.
3. *Zaphrentis phrygia*. Various views of silicified specimens weathered from matrix. Upper foot of the *Brevispirifer gregarius* zone. Falls of the Ohio.
4. *Favosites turbinatus*. Internal view of weathered specimen showing radiating form of corallites (X 2). Upper foot of the *Brevispirifer gregarius* zone. Falls of the Ohio.
5. *Striatopora cavernosa*. Side view of fragment of branch. Upper foot of the *Brevispirifer gregarius* zone. Falls of the Ohio.

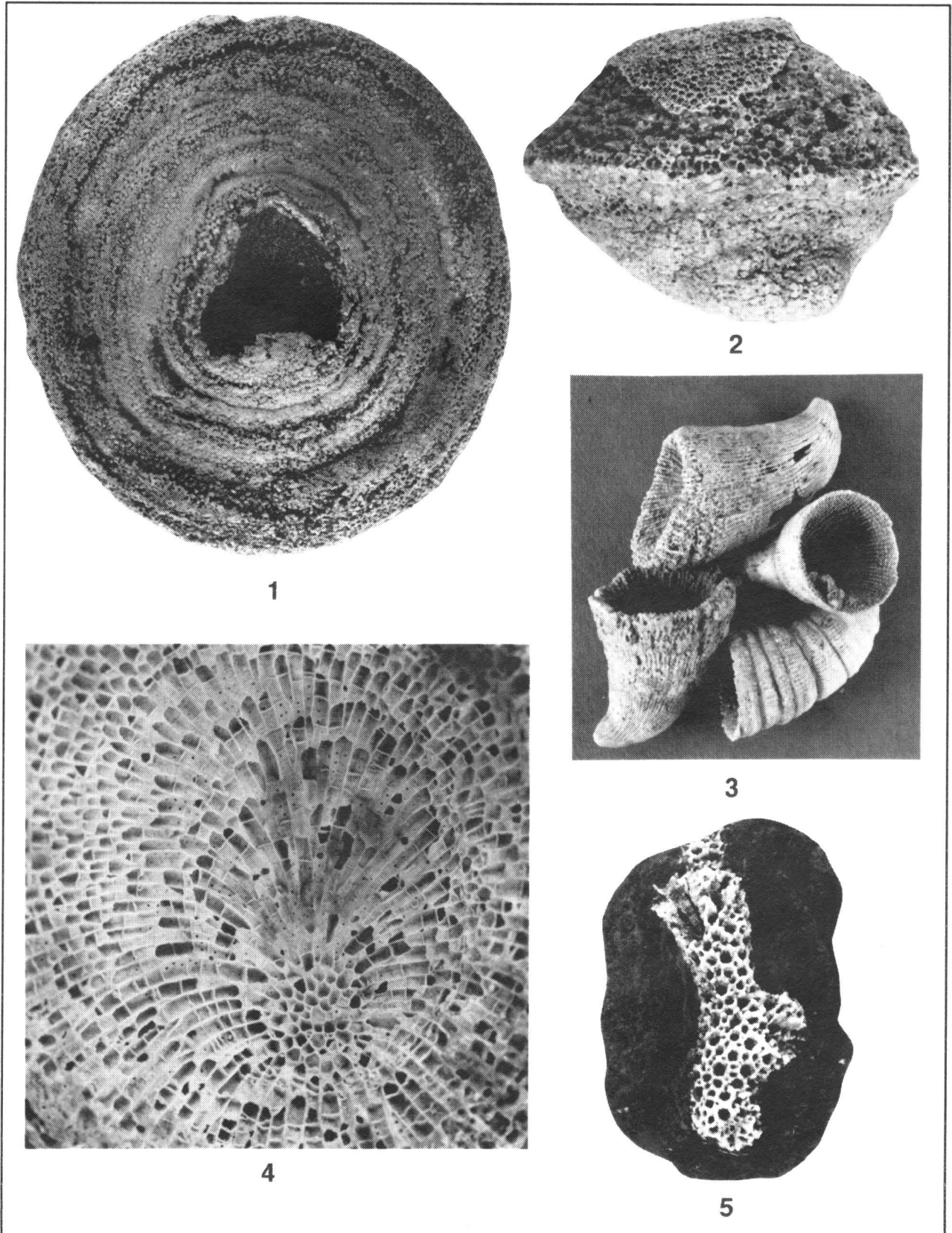


PLATE 6

PLATE 7

Representative fossils of the Jeffersonville Limestone *Brevispirifer gregarius* zone (all figures X 1 unless otherwise noted).

Figure

1. *Turbonopsis shumardi*. Apical view. Falls of the Ohio.
2. Stromatoporoid encrusting *Turbonopsis shumardi* snail. (A) Top and (B) basal views. Falls of the Ohio.
3. *Chonostegites tabulatus* encrusting *Heterophrentis duplicata*. (A) Side and (B) top views. Falls of the Ohio.
4. Stromatoporoid encrusting *Prismatophyllum* coral. Top view (X 0.6). Falls of the Ohio.

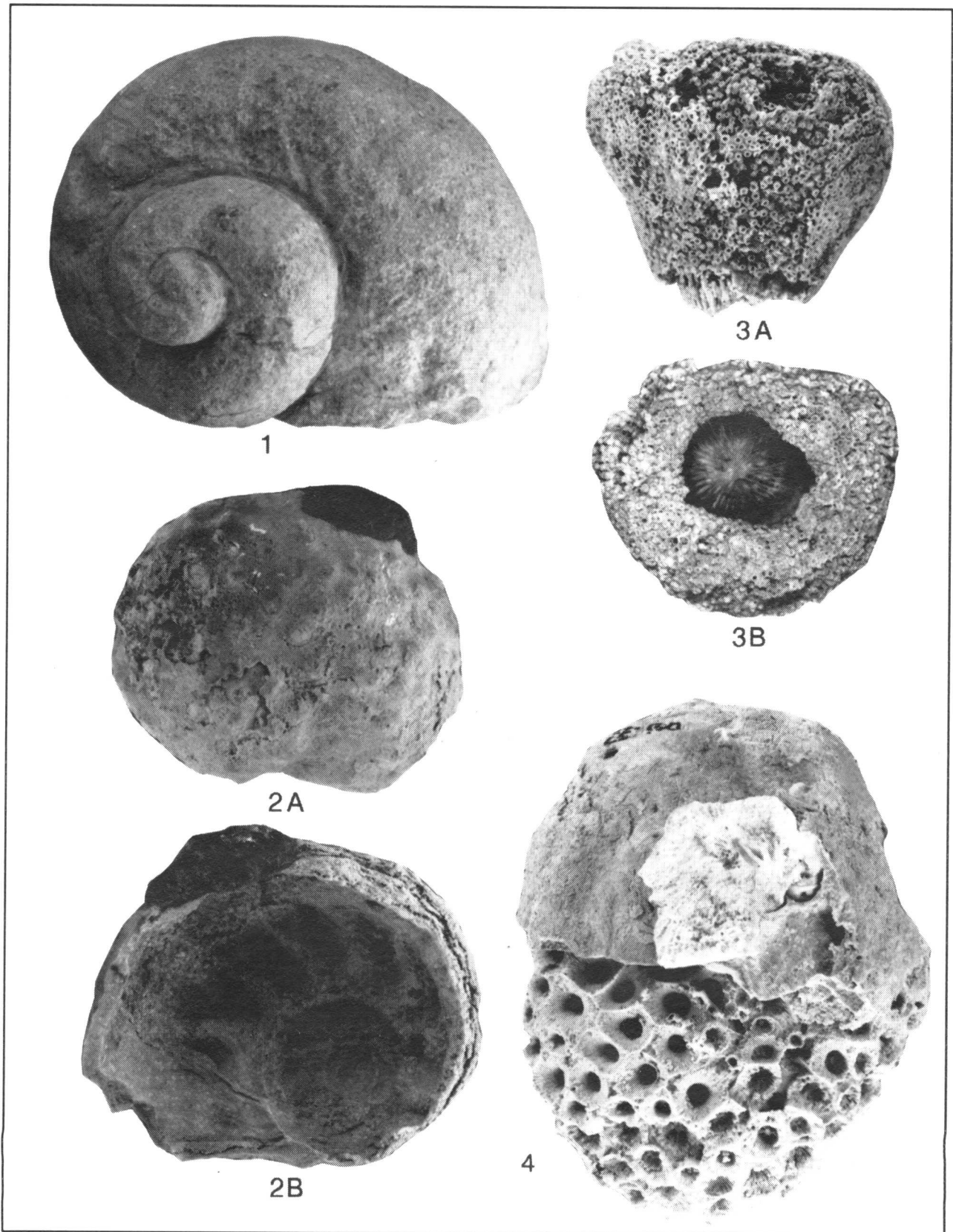


PLATE 7

PLATE 8

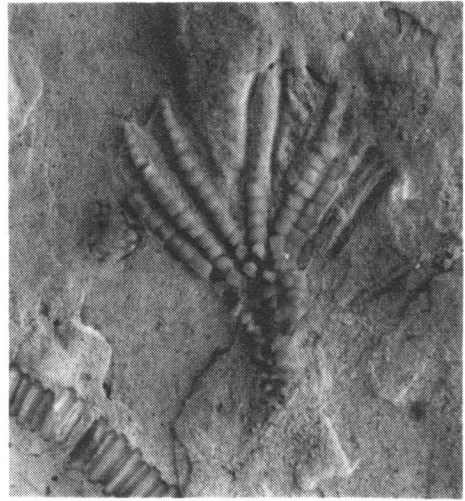
Representative fossils of the Jeffersonville Limestone *Brevispirifer gregarius* zone (all figures X 1 unless otherwise noted).

Figure

1. Crystalline molds of unidentified clams. Upper foot of *Brevispirifer gregarius* zone. Falls of the Ohio. Scale: 5.75 inches (14.5 cm).
2. Unidentified crinoid. Middle *Brevispirifer gregarius* zone. Charlestown, Indiana.
3. Mound-shaped stromatoporoid. Side view (X 0.8). Upper *Brevispirifer gregarius* zone. Charlestown, Indiana.
4. *Stropheodonta* sp. Pedicle view. Upper *Brevispirifer gregarius* zone. Falls of the Ohio.
5. *Brevispirifer gregarius*. Various views. Location uncertain.



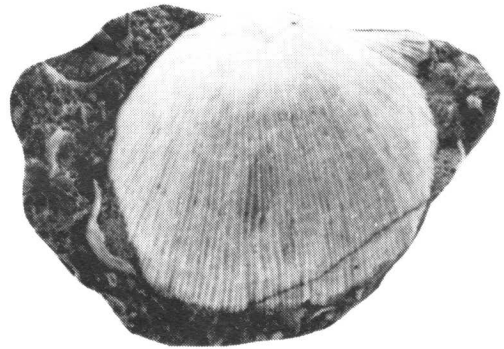
1



2



3



4



5

PLATE 8

PLATE 9

Representative fossils of the Jeffersonville Limestone fenestrate bryozoan-brachiopod and *Paraspirifer acuminatus* zones (all figures X 1 unless otherwise noted).

Figure

1. *Siphonophrentis elongata*. (A) Side and (B) top views of a large broken specimen. Fenestrate bryozoan-brachiopod zone. Falls of the Ohio.
2. Fenestrate bryozoan. Side view of broken colony. Fenestrate bryozoan-brachiopod zone. Falls of the Ohio.
3. *Platyceras dumosum*. Side view. In life, the surface of the snail's shell was covered with hollow spines. Fenestrate bryozoan-brachiopod zone. Falls of the Ohio.
4. *Dolatocrinus lacus*. (A) Top, (B) basal, and (C) side views. Fenestrate bryozoan-brachiopod zone. Falls of the Ohio.
5. *Coronura aspectans*. Ventral view of partial pygidium. Fenestrate bryozoan-brachiopod zone. Falls of the Ohio.
6. *Elaeacrinus verneuili*. Various views of three specimens. Fenestrate bryozoan-brachiopod zone and *Paraspirifer acuminatus* zone. Falls of the Ohio.

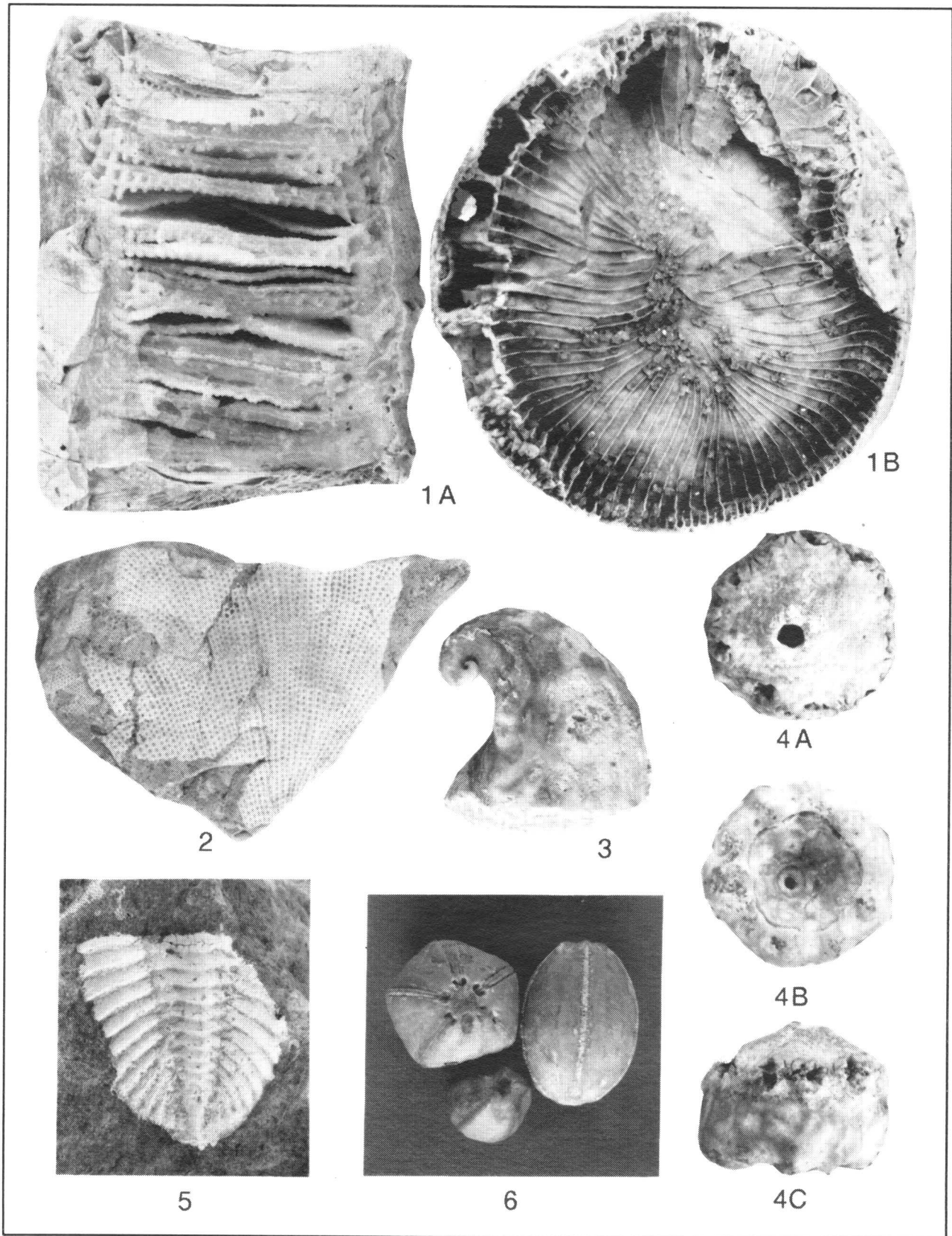


PLATE 9

PLATE 10

Representative fossils of the Jeffersonville Limestone fenestrate bryozoan-brachiopod and *Paraspirifer acuminatus* zones (all figures X 1 unless otherwise noted).

Figure

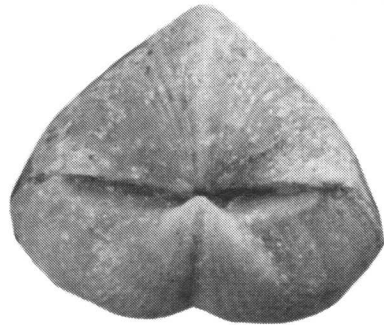
1. *Eridophyllum* sp. Colony in bedrock. Pocket knife is 4 inches long. Fenestrate bryozoan-brachiopod zone. Falls of the Ohio.
2. *Stropheodonta* sp. Brachial valve interior. Fenestrate bryozoan-brachiopod zone. Falls of the Ohio.
3. *Paraspirifer acuminatus*. (A) Posterior and (B) anterior views. *Paraspirifer acuminatus* zone. Scottsburg, Indiana.



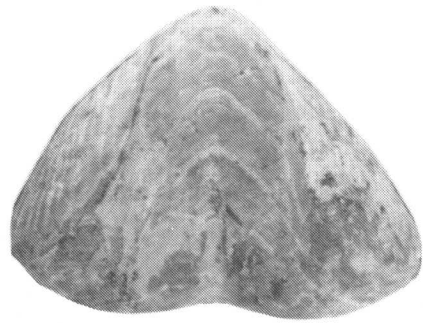
1



2



3A



3B

PLATE 11

Representative fossils of the North Vernon Limestone (all figures X 1 unless otherwise noted).

Figure

1. *Spinocyrtia (Platyrachella) oweni*. (A) Pedicle and (B) brachial views. Silver Creek Member. Jeffersonville, Indiana.
2. *Spinocyrtia euruteines*. (A) Pedicle and (B) brachial views. Silver Creek Member. Jeffersonville, Indiana.
3. *Atrypa* sp. (A) Brachial and (B) pedicle views. Silver Creek Member. Jeffersonville, Indiana.
4. *Trachypora* sp. Side view of fragment of colony. Silver Creek Member. Jeffersonville, Indiana.
5. *Spinocyrtia (Platyrachella) oweni*. Broken specimen, showing silicified spires. Silver Creek Member. Jeffersonville, Indiana.
6. *Paracyclas elliptica*. View of silicified specimen. Silver Creek Member. Jeffersonville, Indiana.
7. *Athyris* sp. Brachial view. Speed Member. Sellersburg, Indiana.
8. *Phacops rana*. Dorsal view of complete specimen (X 1.2). Speed Member. Sellersburg, Indiana.
9. *Phacops rana*. Dorsal view of complete, enrolled, silicified specimen (X 1.2). Silver Creek Member. Jeffersonville, Indiana.
10. *Hadrophyllum orbigny*. Top and bottom views. Speed Member. Charlestown, Indiana.

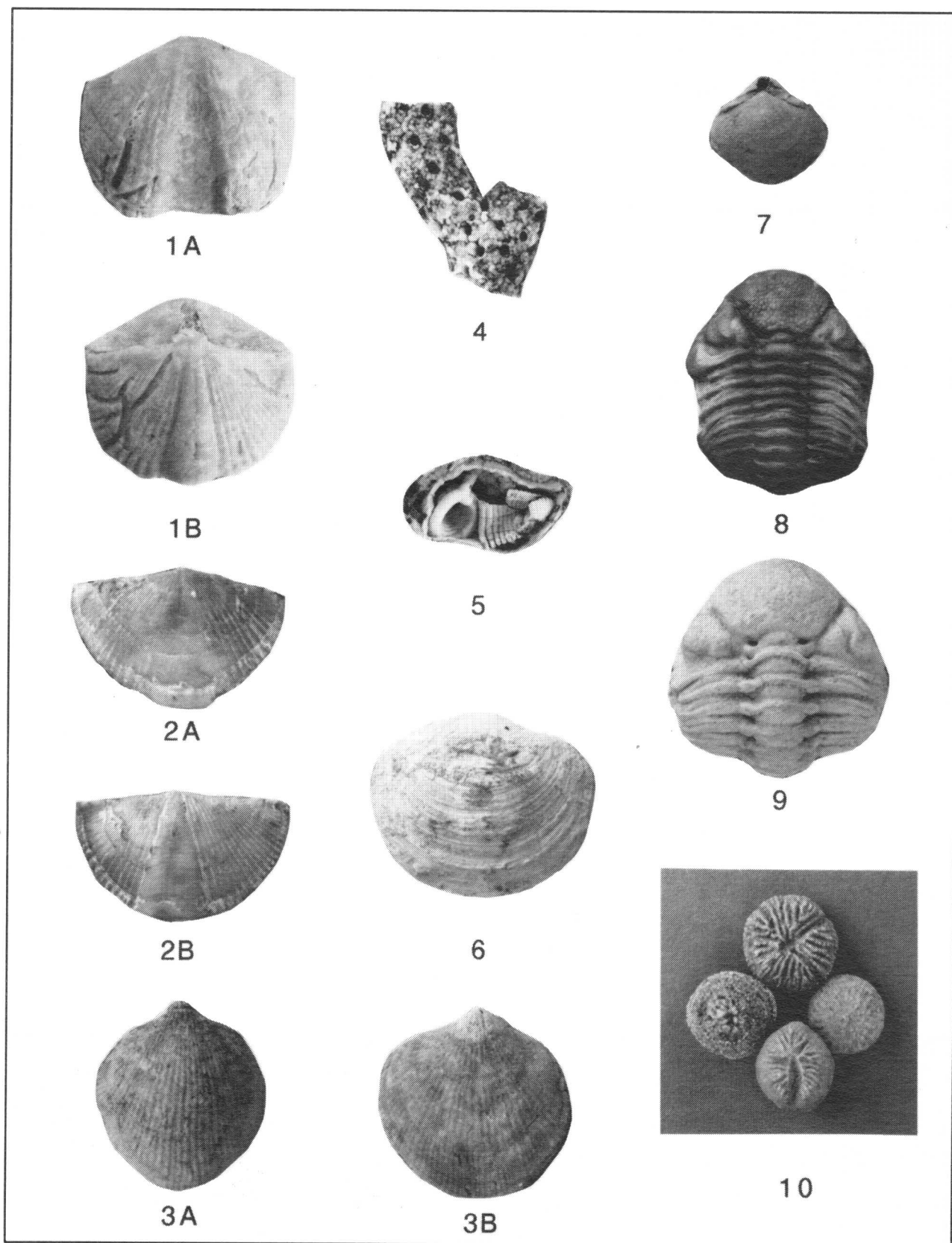


PLATE 11

PLATE 12

Representative fossils of the North Vernon Limestone (all figures X 1 unless otherwise noted).

Figure

1. Chonetid brachiopods, commonly assigned to the species *C. yandellanus*. Silver Creek Member. Jeffersonville, Indiana.
2. *Siphonophrentis halli*. Beechwood Member. Jeffersonville, Indiana.
3. *Megistocrinus* sp. (A) Top, (B) basal, and (C) side views. Beechwood Member. Sellersburg, Indiana.
4. *Aulocystis* sp. Beechwood Member. Jeffersonville, Indiana.
5. Placoderm bone. Beechwood Member. Bardstown, Kentucky.

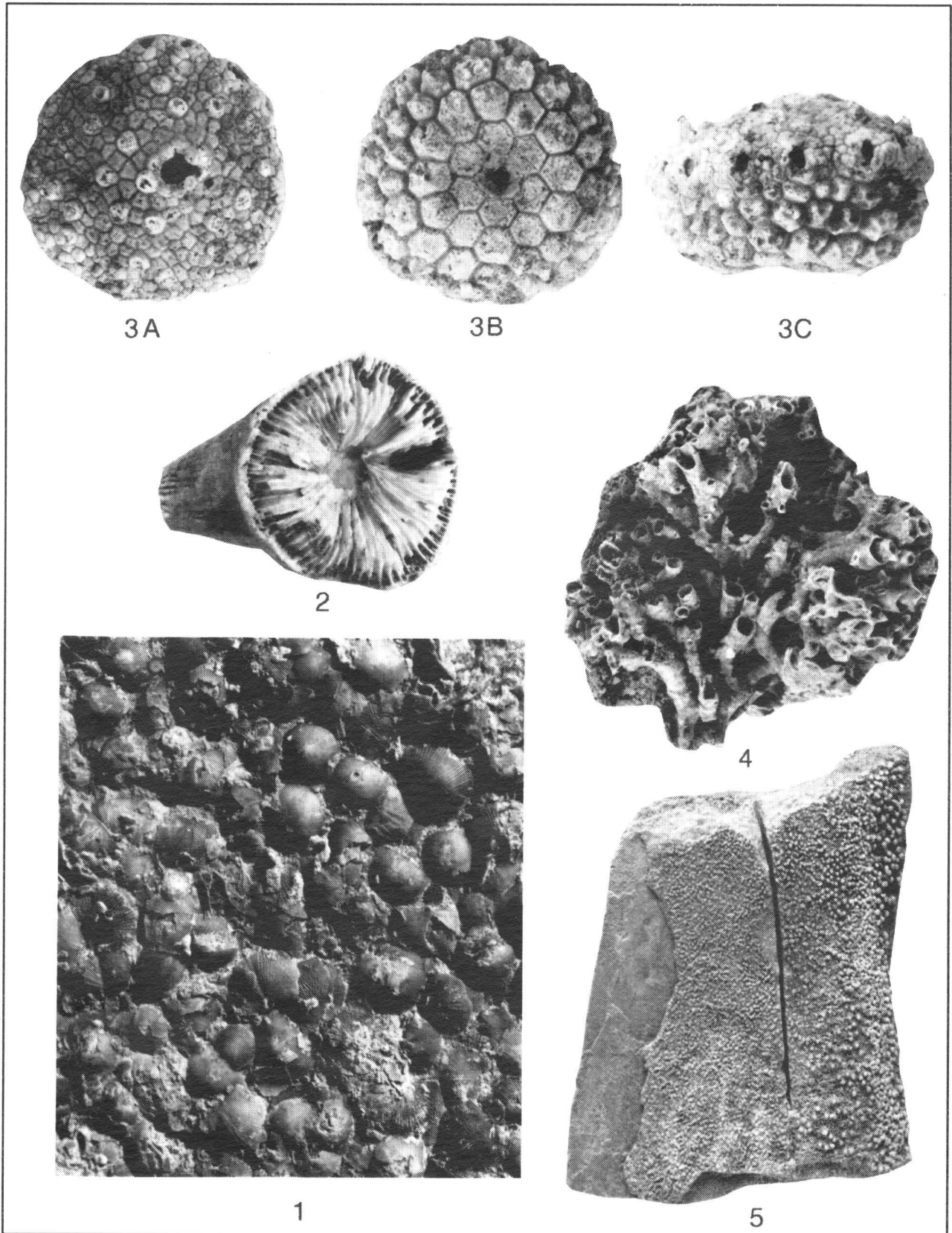


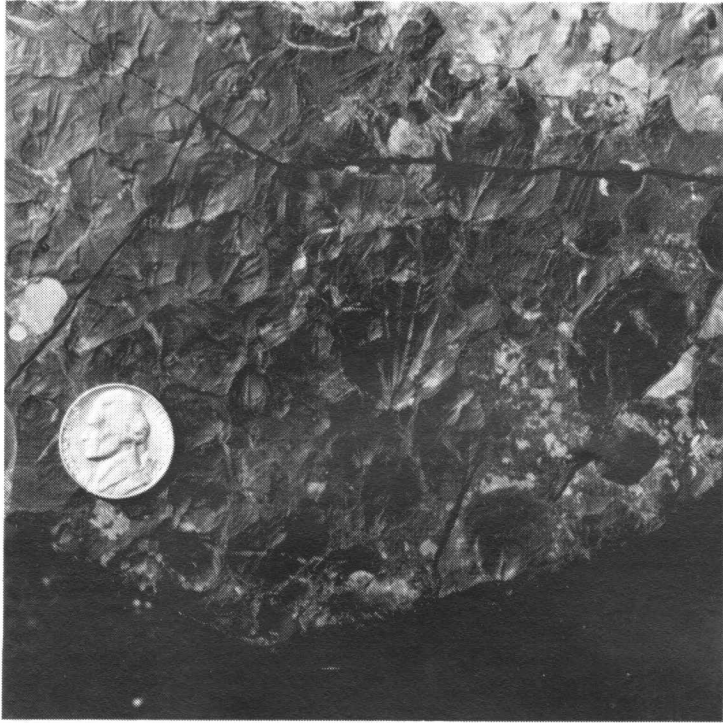
PLATE 12

PLATE 13

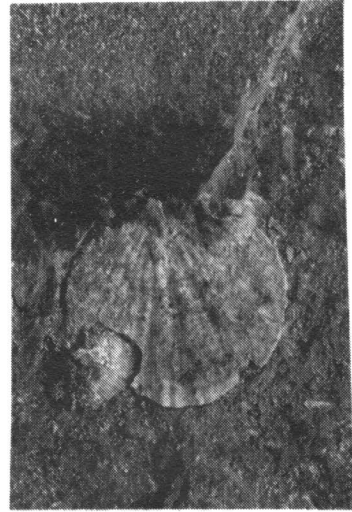
Representative fossils of the New Albany Shale (all figures X 1 unless otherwise noted).

Figure

1. Chonetid brachiopods. Blocher Member. North Vernon, Indiana.
2. "*Leiorhynchus*." Dozens of specimens on black shale, probably representing an in situ community. Coin for scale. Blocher Member. North Vernon, Indiana.
3. "*Leiorhynchus*." Single specimen with a small chonetid. Blocher Member. North Vernon, Indiana.
4. Lingulid brachiopods. Blocher Member. New Albany, Indiana.



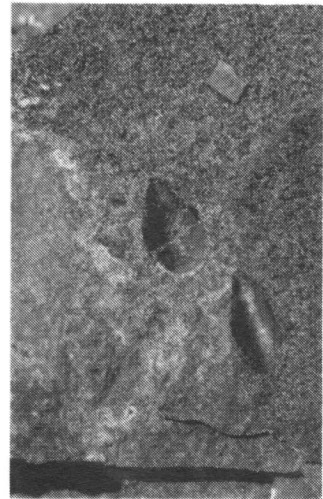
2



3



1



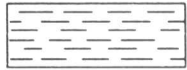
4

PLATE 13

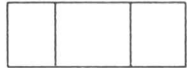


APPENDIX B:
Measured Sections

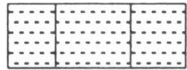
EXPLANATION OF SYMBOLS



Shale



Limestone



Argillaceous limestone



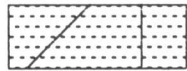
Dolostone



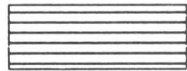
Argillaceous dolostone



Dolomitic limestone/calcareous dolostone



Argillaceous dolomitic limestone/calcareous dolostone



Laminated dolostone



Crossbedding



Mudcracks



Unconformity



Stylolite



Calcite pseudomorph after gypsum



Chert



Chert nodule



Vug



Calcite-filled vug



Fossil mold



Pyrite



Glauconite



Solitary rugose coral



Branching coral colony



Chain coral



Mound-shaped coral colony



Mound-shaped stromatoporoid



Mat-shaped stromatoporoid



Paraspriifer acuminatus



Brevispirifer gregarius



Miscellaneous brachiopod



Amphipora ramosa



Pelmatozoan



Gastropod



Platyceras dumosum



Fenestrate bryozoan



Platy bryozoan



Hippocardia cunea



Trilobite



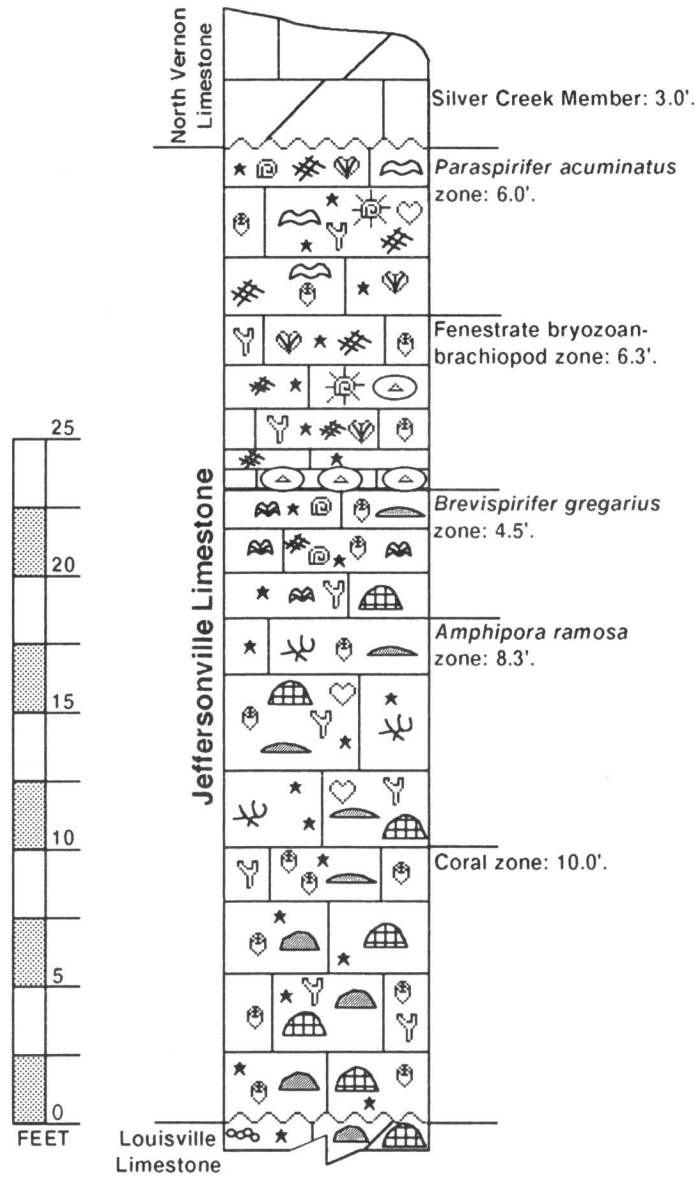
Pelecypod



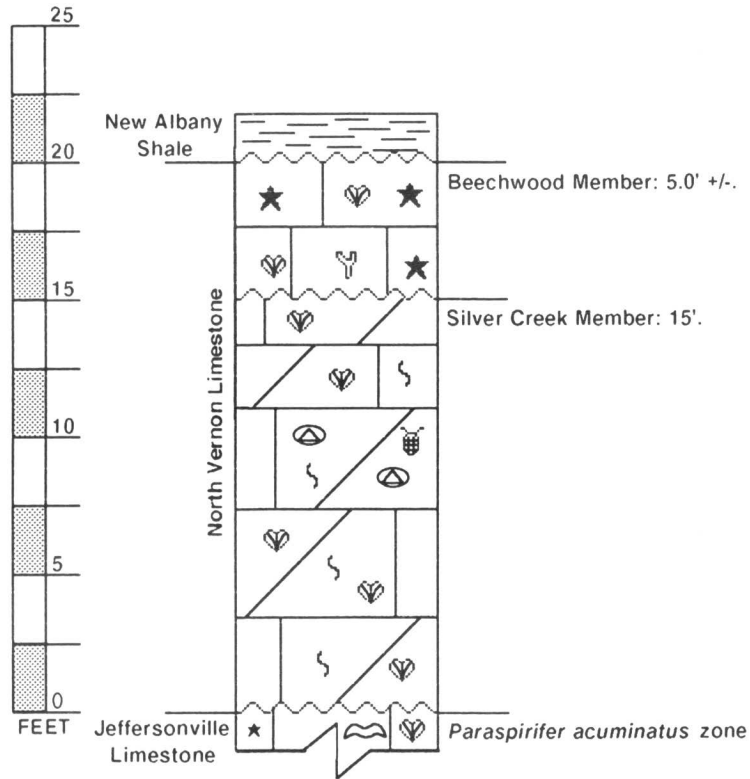
Charophyte oogonia



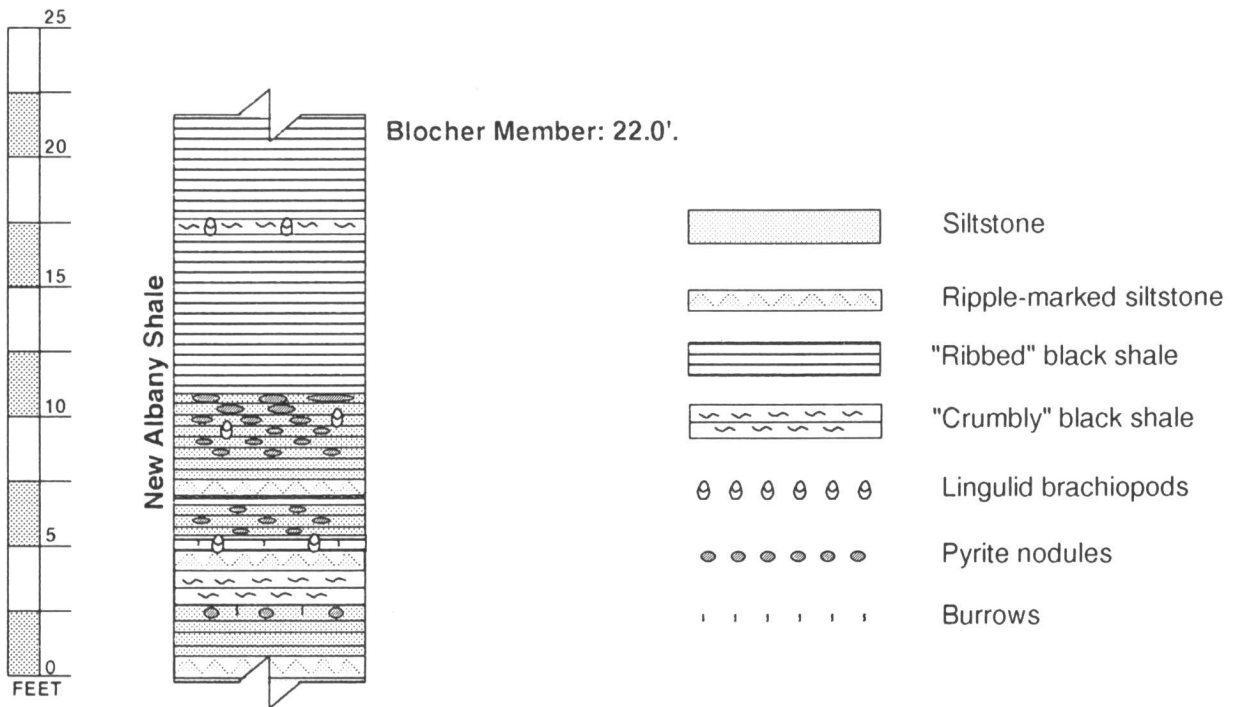
Burrow



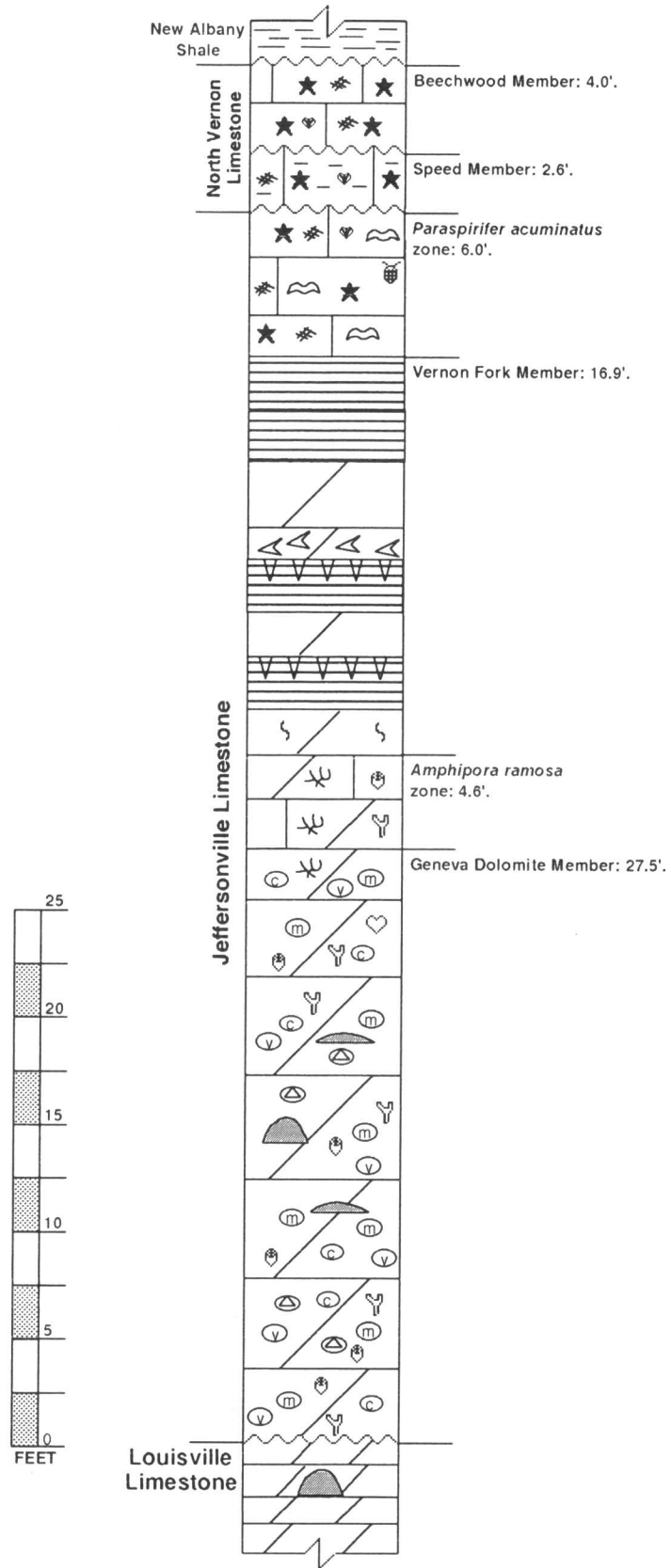
Devonian Carbonate Section:
Stop 1



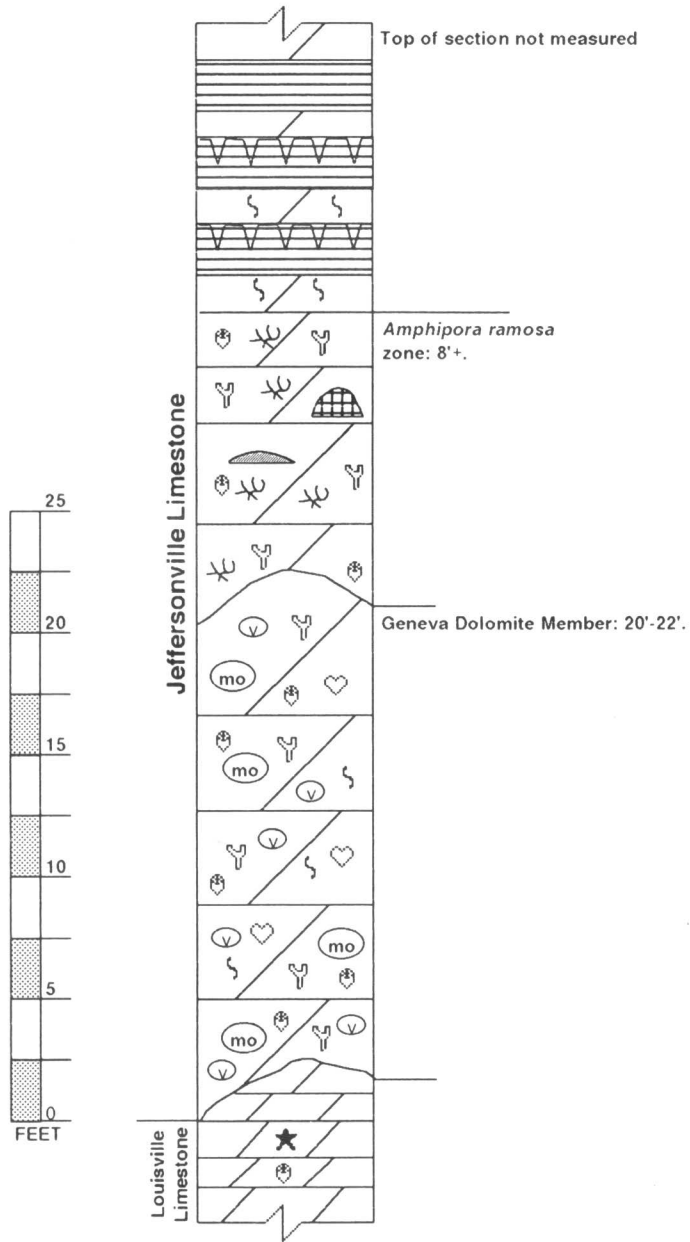
**Devonian Carbonate Section:
Stop 2**



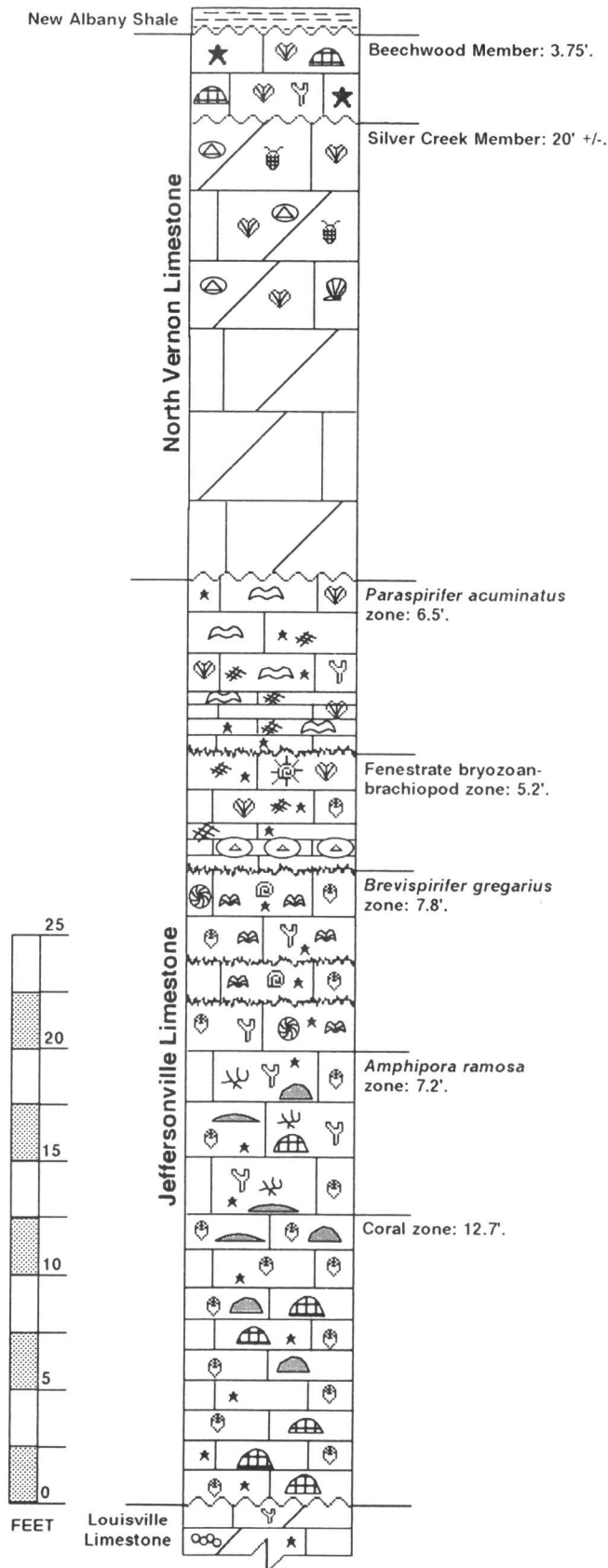
**Devonian Shale Section:
Stop 3**



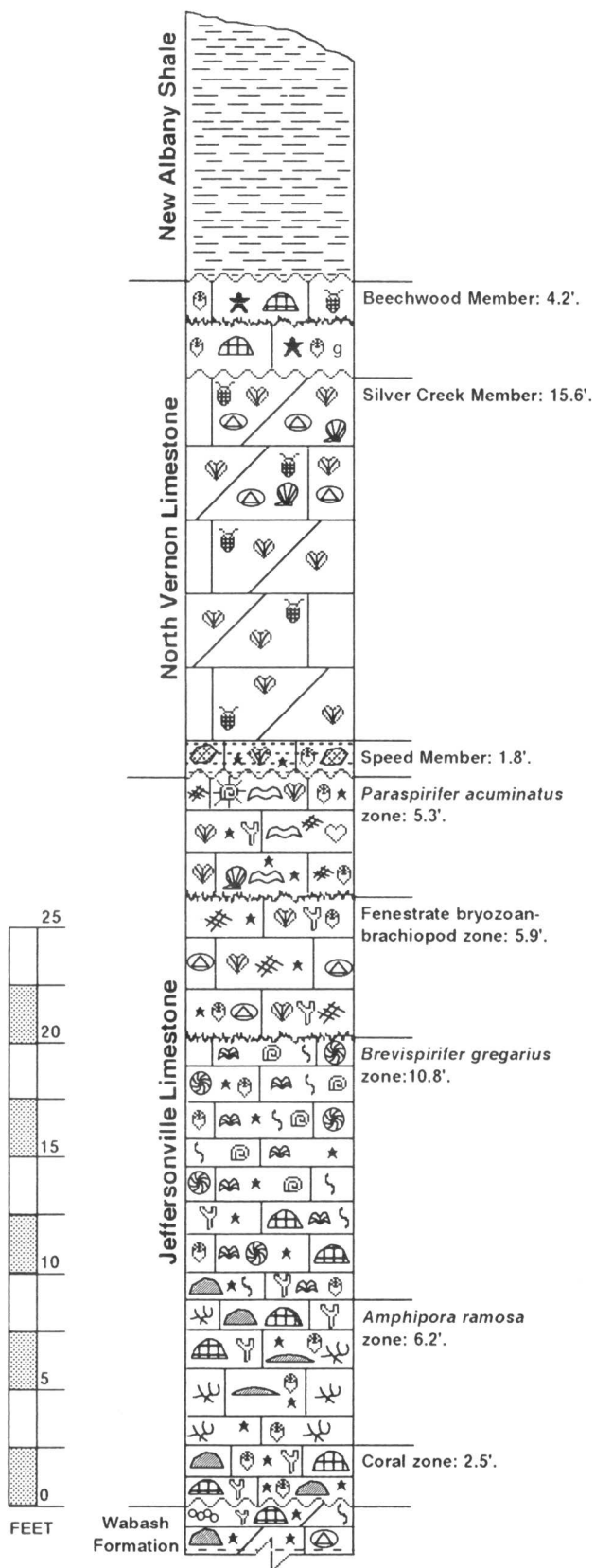
Devonian Carbonate Section:
Stop 4



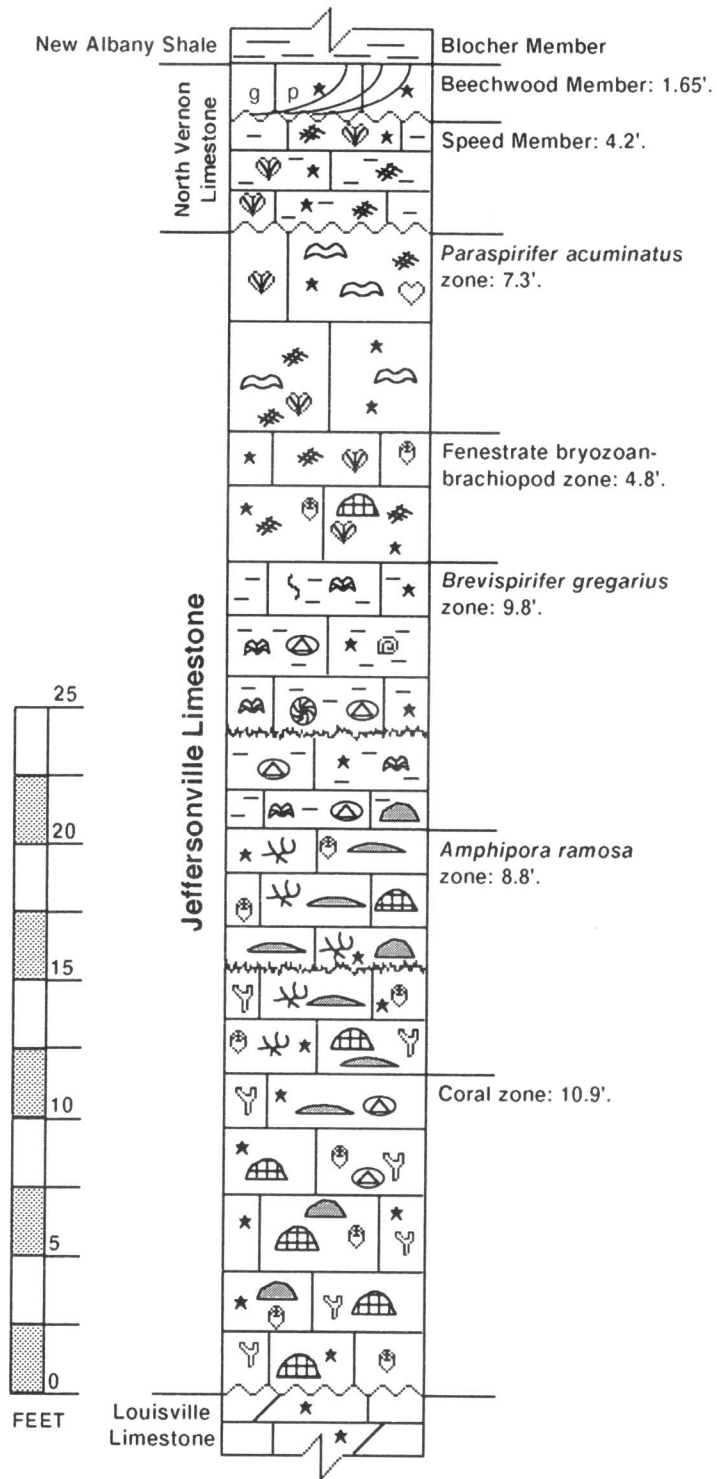
Devonian Carbonate Section:
Stop 5



Devonian Carbonate Section:
Stop 6



Devonian Carbonate Section:
Stop 7



Devonian Carbonate Section:
Stop 8

