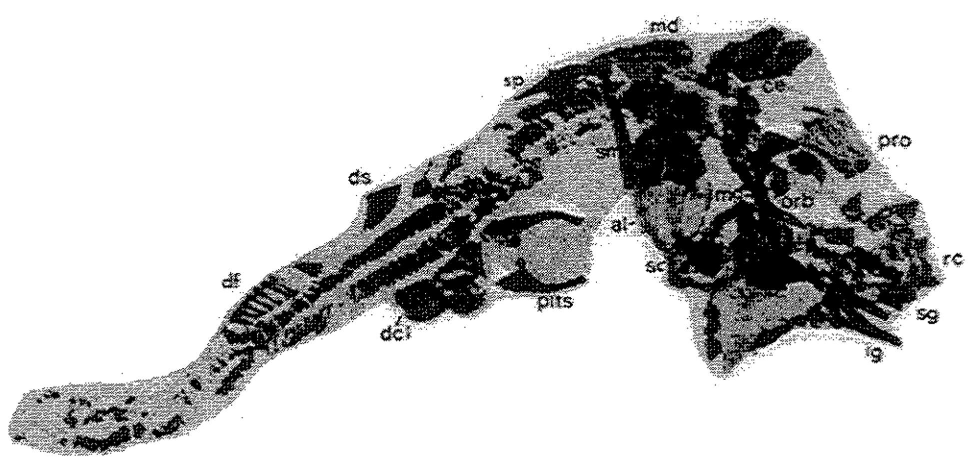
PALEOZOIC STRATIGRAPHY OF THE QUAD-CITIES REGION EAST-CENTRAL IOWA, NORTHWESTERN ILLINOIS

Field Trip Coordinators:
William Hickerson and Richard C. Anderson



Geological Society of Iowa

April 24, 1994 **Guidebook No. 59**

Cover illustration: Ptyctodontid skeleton from the upper Spring Grove Member of the Pinicon Ridge Formation. Laterally compressed male ptyctodontid of the gracile type. Abbreviations used: sg=supragnathal, ig=inferognathal, mg=marginal, orb=orbit, rc=rostral cartilage, pro=preorbital, sm=submarginal, md=medial dorsal, adl=anterior dorsal lateral, al=anterior lateral, sca=pelvic scales, ds=dorsal spine, df=dorsal fin, dcl=dermal claspers, plfs=pelvic fin support, ?pa=unidentified paired appendage. (photograph by William Hickerson)

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Edited by
Bill J. Bunker

with contributions by
Brian J. Witzke, Curtis R. Klug, Greg Castrey,
Richard L. Leary, Jed Day, William Koch,
and Donald G. Mikulic

Geological Society of Iowa

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INTRODUCTION

William Hickerson and Richard C. Anderson
Department of Geology, Augustana College
Rock Island, Illinois

The 1994 Spring Meeting field trip of the Iowa Geological Society will examine the Paleozoic rocks in the Quad-Cities region. In this area the broad, low Mississippi River Arch projects southward from the southwestern flank of the much larger Wisconsin Arch, structures that define the northwestern limit of the Illinois Coal Basin. In a sense, the Quad-Cities region lies at a "crossroads" spanning not only the Mississippi River and a state boundary but significant geological boundaries, as well.

Thus the Pennsylvanian rocks of Scott and Muscatine counties in Iowa, at the extreme northwestern limit of the Illinois Coal Basin, probably have closer affinities to the Pennsylvanian in Illinois than they do to the Pennsylvanian farther west in Iowa. In contrast, the Devonian rocks of the Quad-Cities region lie at the southeast limit of a broad outcrop belt that extends northwestward across Iowa; they bear closer affinities to the Devonian of the Iowa Basin than they do to the Devonian of the Illinois Basin. Likewise, the Quad-Cities region represents the southernmost exposures of Silurian rocks in northwestern Illinois and are a continuation of the Silurian exposures on the southwestern flank of the Wisconsin Arch in Iowa. They have closer affinities to the Silurian of Iowa than they do to the Silurian of northeastern Illinois and eastern Wisconsin.

The object of this field trip is to examine these rocks, all of which lie at an extremity of one kind or another, and to consider their relationship to adjacent rocks that lie on the other side of structural or political boundaries.

We will begin at the Allied Quarry, where the Silurian and Devonian are well exposed on the north highwall. Although Silurian rocks are well exposed here, they are not readily accessible, and the emphasis will be on the Pinicon Ridge Formation and the lower Little Cedar Formation (Middle Devonian; Witzke and others, 1988). Pennsylvanian is also present.

The second stop is the Milan Stone Quarry. The upper part of the Silurian section is accessible here as is most of the Pinicon Ridge Formation. The Solon Member of the Little Cedar Formation occurs at the top of the highwall, and the Solon and Rapid members can be seen at the far southeast corner of the quarry. Several fine examples of paleokarst, both sinkholes and caves, with a fill of Pennsylvanian shale, sandstone, and comglomerate can be seen in the quarry walls. In places dripstone occurs on the walls of these filled caves.

Stop three, which will be after lunch, is the Buffalo, Iowa, Quarry of the LaFarge Corporation's Davenport Cement Plant. This is an important reference section for the Middle Devonian of eastern and northeastern Iowa (Witzke and others, 1988). Otis, Pinicon Ridge, Little Cedar, Coralville, and Lithograph City formations are all well exposed. In addition, the Sweetland Creek Formation (Upper Devonian) is present, and a thin cover of Pennsylvanian sediment also occurs.

The final stop will be at Wyoming Hill in eastern Muscatine County, Iowa. This is the best exposure of the Pennsylvanian in the Quad-Cities region. The sediments are Morrowan and possibly Desmoinesian in age and represent the northwesternmost Pennsylvanian of the Illinois Coal Basin (Ravn and others, 1984).

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SILURIAN STRATIGRAPHY IN THE QUAD CITIES AREA, IOWA-ILLINOIS

Brian J. Witzke
Iowa Department. of Natural Resources
Geological Survey Bureau
Iowa City, IA 52242-1319

INTRODUCTION

Pervasively dolomitized Silurian carbonate rocks are exposed along resistant valley walls and in quarry operations and roadcuts scattered across the broad region of eastern Iowa and adjacent northwestern Illinois. The southermost extremity of the Silurian outcrop belt in this region is found in the general Quad Cities area, which includes exposures in Scott County, Iowa, and portions of Henry, Whiteside, and Rock Island counties, Illinois. Silurian dolomite strata are covered by younger Devonian and Pennsylvanian units progressing southward within the area of the Quad Cities. Silurian carbonate sediments were deposited within a broad structural low across eastern Iowa that has been termed the East-Central Iowa Basin (Bunker et al., 1985), and the Quad Cities occupy a general position in the southern portion of this stratigraphic basin. In general, Silurian stratigraphic units thicken northward from the Quad Cities within the Silurian outcrop, but strata are erosionally beveled in that direction due to post-Devonian uplift and erosion of the central and northern part of the East-Central Iowa Basin area.

The history of Silurian stratigraphic nomenclature in the area is complex and somewhat confusing (see Witzke, 1992), and the details will not be repeated here. However, a few notes pertinent to the Quad Cities area are appropriate, especially the pivotal role that certain observations in the area played in the nomenclatural development. The relatively youthful and constricted Mississippi River Valley north of the Quad Cities once included navigational hazards at the LeClaire rapids, where the river riffled over Silurian bedrock ledges. Silurian exposures at LeClaire, Iowa, were first named the "limestone of LeClaire rapids" by Hall and Whitney (1858), who recognized a horizontally bedded to "folded" sequence of hard dolomite, in part with abundant brachiopod and rugose coral molds. Worthen (1862) subsequently recognized that the "LeClaire Limestone" is intercalated with horizontally-laminated rocks in the LeClaire area. Later studies incorporated the LeClaire as a facies or member within the Gower Formation (named for exposures in Cedar Co., Iowa). The LeClaire has been adopted as a name for "reefal" Silurian dolomites by numerous workers in other parts of eastern Iowa, but the unit is probably restricted in outcrop to the general Quad Cities area (Witzke, 1992). Of interest, the terms LeClaire or Gower have generally not been applied to equivalent Silurian rocks across the Mississippi River in Illinois, where an independent Silurian stratigraphic nomenclature has developed.

Savage (1926, 1942) erected a stratigraphic nomenclature for northwestern Illinois that did not utilize any of the existing names previously defined in Iowa. Instead, Savage's nomenclature was a mixture of terminology derived primarily from localities in eastern Wisconsin and northeastern Illinois, as well as some new units named from localities in the Quad Cities area (the Cordova and Port Byron dolomites). Unfortunately, Savage's stratigraphic scheme proved to be largely ill founded (Willman, 1973), and, although remarkable, it is now apparent that "Savage had miscorrelated all Silurian units in the area" of northwestern Illinois (Witzke, 1992, p. 7). The only term introduced by Savage that may have some degree of stratigraphic meaning is his Port Byron Dolomite, even though Savage over-applied this name to include strata as low as the upper Hopkinton in some of his sections. In a stricter sense of the term derived from the type area of Port Byron, Illinois, the Port Byron Dolomite is clearly a stratigraphic equivalent of the LeClaire Dolomite, whose type locality lies directly across the river from Port Byron.

Willman (1973) proposed new names to replace Savage's inappropriate nomenclature in northwestern Illinois, and he introduced some terminology previously erected in eastern Iowa for part of the Lower Silurian interval. Willman, however, did not extend previously defined Iowa stratigraphic nomenclature into the middle and upper parts of the Silurian section in northwestern Illinois. Instead, Willman (1973) assigned all strata above the newly-named *Pentamerus*-bearing Marcus Formation to the Racine Formation, a unit whose type locality is in southeastern Wisconsin. He did not retain the Port Byron as a stratigraphic name, assigning this interval to the "upper Racine" in the Quad Cities area. Witzke (1992) questioned Willman's use of the term "Racine" in northwestern Illinois, and suggested that the "Racine" has been misapplied in the area. Willman did not reconcile or adopt most previously named and correlative units across the Mississippi River in eastern Iowa, particularly the Hopkinton, Gower, and LeClaire.

Studies in the 1970s and 1980s, especially those of Johnson (1975, 1983) and Witzke (1981, 1985, 1992) clarified and refined the historic stratigraphic nomenclature developed in eastern Iowa. These workers incorporated Willman's Illinois stratigraphic units within the existing Iowa framework that included the long recognized Hopkinton and Gower formations. A new unit, the Scotch Grove Formation, was proposed by Witzke (1985) for strata that were excluded from the original definitions of the Hopkinton and Gower formations, an interval that was mistakenly relegated to the lower and/or middle "Racine" Formation in northwestern Illinois by Willman (1973). Only the upper part of the Scotch Grove, with its distinctive mound facies, may actually correlate with part of the typical Racine sequence. Much of Willman's "Racine" section in northwestern Illinois, in fact, correlates with pre-Racine strata to the east (the Joliet Fm and its equivalents).

The Gower Formation of eastern Iowa and adjacent Illinois probably correlates with part of the lower and middle Racine sequence in eastern Wisconsin and northeastern Illinois. The Gower Formation has been applied to Silurian strata in the Quad Cities area since its inception (Norton, 1899), and its use there has clear historic precedence over any subsequent reassignment to other stratigraphic units (Port Byron Dolomite of Savage, 1926, 1942; modified "Racine" Formation of Willman, 1973). To be sure, mound facies of the Gower and Racine share many lithic and faunal similarities, but the formations show significant lithic variations in their intermound (inter-reef) facies. Gower intermound strata (Anamosa Member) are characterized by unfossiliferous laminated dolomite relatively free of chert and argillaceous material. By contrast, Racine intermound facies are commonly cherty (especially near mound margins) and argillaceous (shaly in part), and units are fossiliferous to varying degrees (with diverse trilobite, brachiopod, crinoid, or graptolite associations). Unlike the Gower, equivalent Racine strata do not display prominently laminated dolomite facies, and the eastern limit of the Gower Formation can be delimited in Illinois at the position where laminated dolomite facies (Anamosa Member) are replaced by non-laminated intermound facies more characteristic of the Racine Formation. Racine strata of eastern Wisconsin and northeastern are known to be replaced further to the east by laminated and evaporitic facies of the lower Salina Group in the Michigan Basin.

The disparate Silurian stratigraphic nomenclature between eastern Iowa and adjacent northwestern Illinois remains highly undesirable, particularly since these two state areas expose exactly equivalent stratigraphic sections and an identical lithic and paleontologic sequence along the Mississippi River Silurian outcrop. This problem is particularly acute in the Quad Cities area. One of the primary aims of this report is to strongly encourage adoption of the existing eastern Iowa nomenclature into adjacent Illinois. The bulk of Willman's Illinois nomenclature has already been adopted for use in the Iowa section (including the Blanding, Sweeney, and Marcus), and the only substantive changes in Illinois would be the incorporation of the Sweeney and Marcus as members within the Hopkinton Formation and the elimination of the Willman's poorly-applied term "Racine" (replaced by units of the upper Hopkinton, Scotch Grove, and Gower formations). The adoption of such changes would allow identical stratigraphic terms to be applied on each side of the Mississippi River. The following stratigraphic summary will procede under the proposition that such changes in Illinois nomenclature are desirable.

SUBSURFACE STRATIGRAPHY

The bulk of the Silurian interval in the Quad Cities area occurs in the subsurface, and only the upper part of the Silurian interval is accessible in outcrop. Subsurface units in the Quad Cities area have been investigated primarily on the Iowa side of the River, mostly from examination of well cuttings and logs stored at the Geological Survey Bureau in Iowa City. Well logs from the Illinois side of the River were provided by the Illinois State Geological Survey in Champaign-Urbana. No subsurface core penetrations were available within the Quad Cities proper, but informative core sections were studied from the area immediately to the north in northern Scott and southeastern Clinton counties, Iowa (presently housed at the Iowa Survey). Further efforts to locate Illinois core sections would be helpful. The general stratigraphic section defined for eastern Iowa is illustrated in Figure 1. Subsurface Silurian units in the Quad Cities are included in the Blanding, Hopkinton, and Scotch Grove formations. The total Silurian section in the Quad Cities area reaches thicknesses between 300 and 400 feet (90-120 m)(see Fig. 2).

Blanding Formation

The Blanding Formation marks the base of the Silurian section in the Quad Cities, where it unconformably overlies shales and shaly carbonates of the Upper Ordovician Maquoketa Formation. Older Silurian units of the Mosalem and Tete des Morts formations are recognized north of the Quad Cities, but these units are overstepped by the Blanding to the south and west (Witzke, 1992). The Blanding Formation is a dolomite unit character-

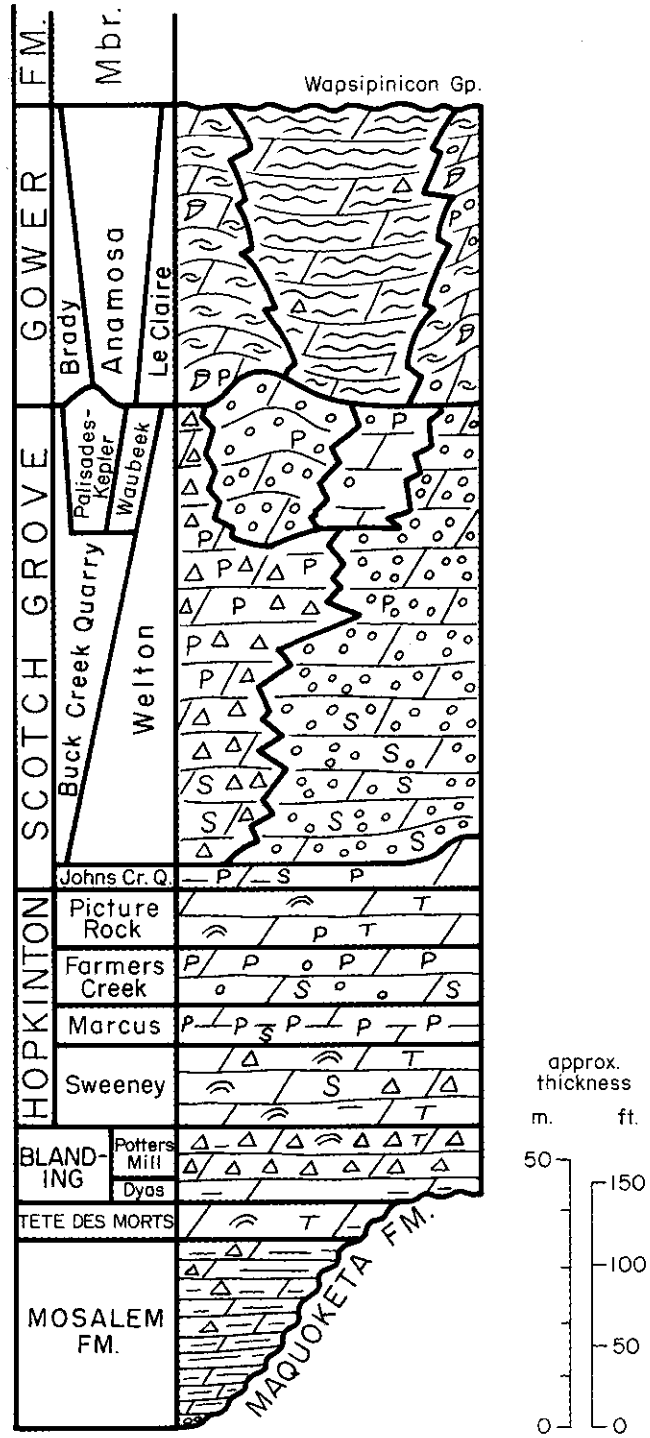

Figure 1. General Silurian stratigraphic section of eastern Iowa (from Witzke, 1992). Symbols as in Figure 3. Additional symbols: wavy lines (laminated dolomite), S (stricklandid brachiopods).

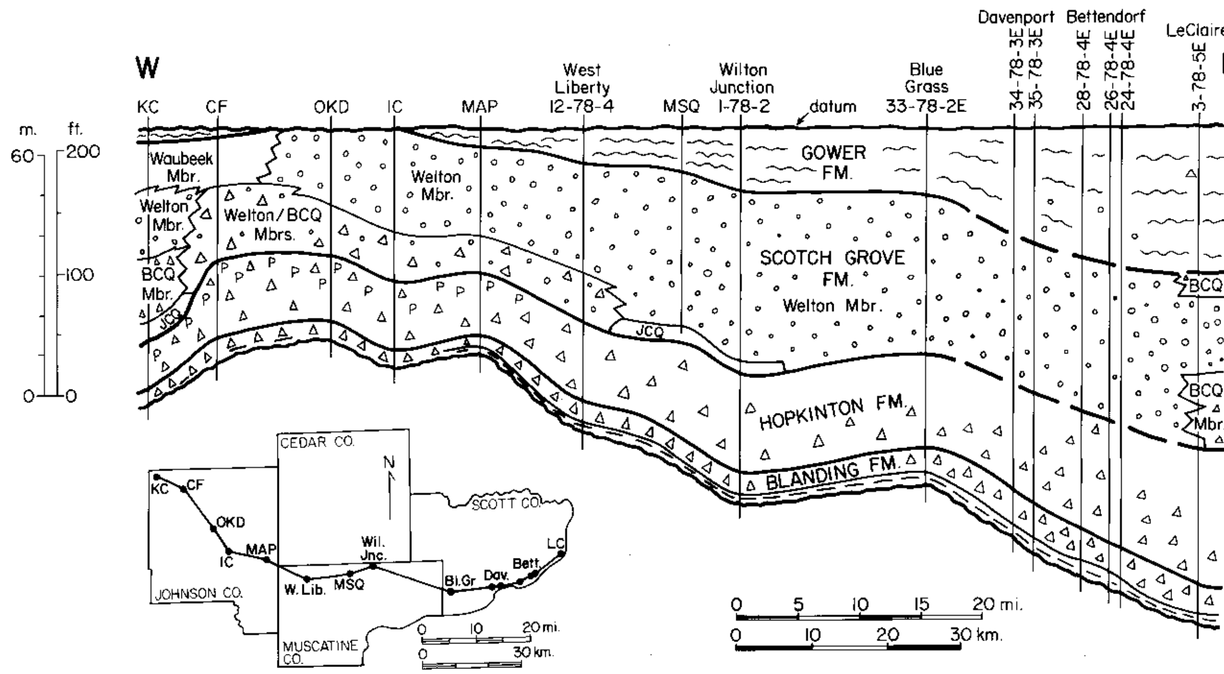

Figure 2. Generalized Silurian cross-section extending from Johnson County to the Quad Cities area, eastern Iowa. Abbreviations: JCQ (Johns Creek Quarry Member), BCQ (Buck Creek Quarry Member). Symbols as in Figures 1 and 3. Datum is top of Silurian. Localities include core penetrations (from Witzke, 1981) and well logs on file at the Iowa DNR-Geological Survey Bureau.

ized by an abundance of chert in nodules and beds (chert content 10-30%), and is the most chert-rich Silurian formation in the Quad Cities. It is argillaceous near the base, and argillaceous stylolitic surfaces are common. The Blanding ranges between 20 and 30 feet (6-9 m) in thickness in the Quad Cities area, but the formation thickens significantly northward into the outcrop belt. The Blanding is of mid-Llandoverian age.

Hopkinton Formation

The Hopkinton Formation is divided into four members, two of which were named by Willman (1973) for localities in Illinois (see Johnson, 1983; Witzke, 1992). The constituent members are distinguishable in core and outcrop (see Chemplex core, southeast Clinton Co., Fig. 3), but the members may be more difficult to recognize in cuttings and well logs. In general, the Hopkinton Formation in the Quad Cities area includes cherty dolomite in the lower half, with non-cherty to slightly cherty dolomite in the upper half. It is less cherty than the underlying Blanding Formation. The Hopkinton is generally about 70 to 90 feet (21-27 m) in thickness in the Quad Cities subsurface, but thickens northward (up to 160 ft; 49 m) in the outcrop belt of eastern Iowa. The Hopkinton is Llandoverian in age (mid Aeronian to mid Telychian).

Although a short distance north of the Quad Cities, the Chemplex core (Fig. 3) can serve to characterize the Hopkinton Formation in the area. The lower Sweeney Member resembles the Blanding Formation, but is generally less cherty and more fossiliferous. Tabulate corals and laminar stromatoporoids, silicified in part, are common, and a horizon with stricklandid brachiopods is recognized near the middle of the member. The overlying Marcus Member resembles the Sweeney, but it is less cherty and contains beds with conspicu-

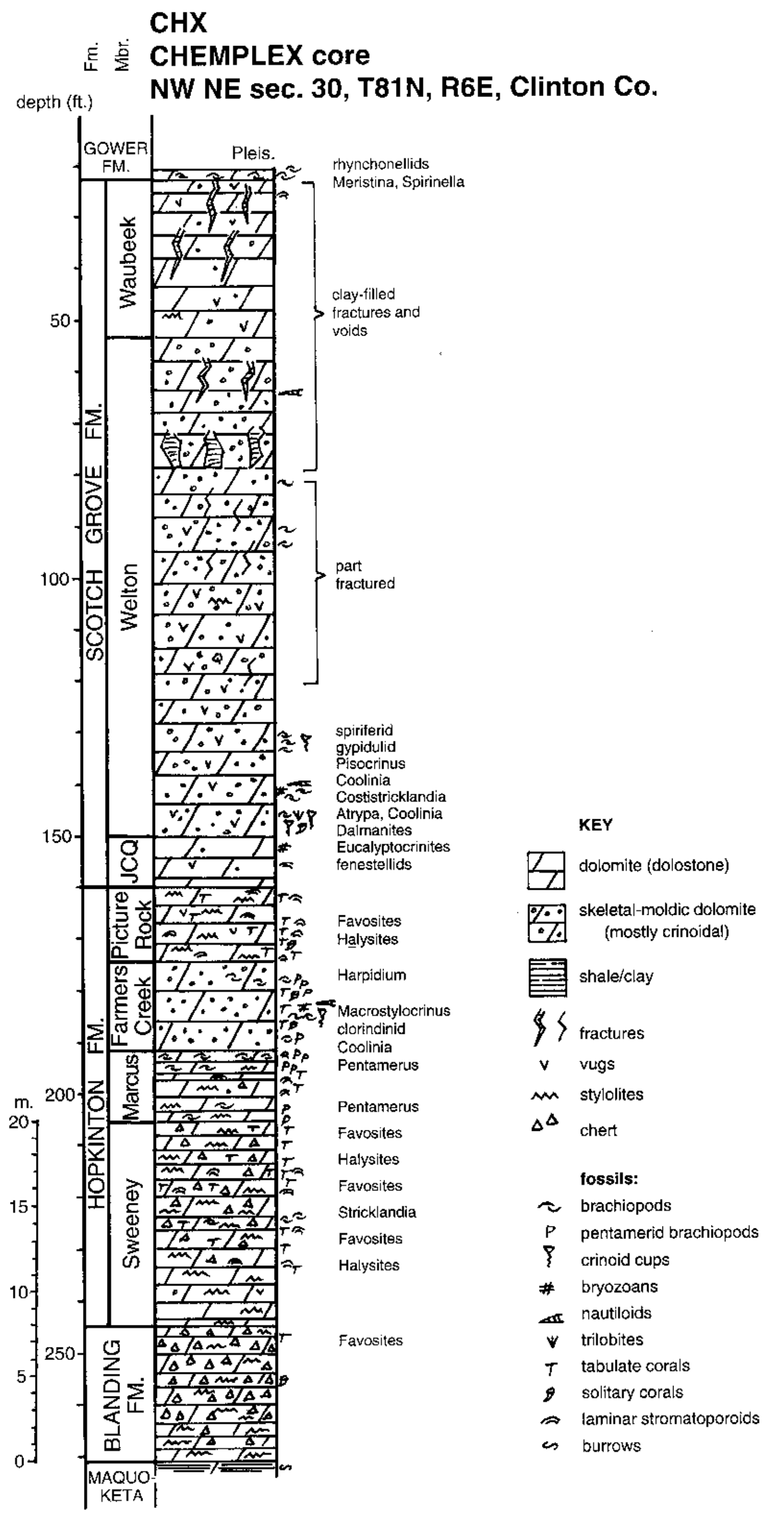

Figure 3. Silurian section displayed in the Chemplex core, Clinton County, Iowa. This is representative of the subsurface stratigraphic section also seen in the Quad Cities area a short distance to the south. Core is stored at the Iowa DNR-Geological Survey Bureau.

ously abundant pentamerid brachiopods (*Pentamerus oblongus*). The Farmers Creek Member lithically contrasts with overlying and underlying Hopkinton units, and is characterized by finely skeletal-moldic dolomites. An abundant and diverse fauna of crinoids and brachiopods is recognized, and small pentamerids (*Harpidium maquoketa*) are commonly noted in the middle to upper parts. The Farmers Creek Member regionally forms the most productive portion of the Silurian aquifer. The uppermost member of the Hopkinton, the Picture Rock, lithically resembles the Sweeney, but is less cherty; a similar fauna of tabulate corals and stromatoporoids occurs in the Picture Rock. The Picture Rock Member was mistakently included in the lower part of the "Racine Formation" by Willman (1973).

Scotch Grove Formation

The Scotch Grove Formation occurs entirely in the subsurface in the immediate Quad Cities area, but the uppermost part of the formation can be seen in outcrop to the north in northern Scott and southern Clinton counties, Iowa, and adjacent areas of Illinois. Where capped by the Gower Formation, it ranges between 120 and 150 feet (35-45 m) in thickness, but Scotch Grove strata significantly thicken northward and northwestward from the Quad Cities into the outcrop belt (where thicknesses of up to 300 feet; 90 m are indicated). The bulk of the formation is characterized by fossil-moldic (especially crinoidal) dolomite, with denser less fossiliferous units at the top and bottom. However, the upper part locally displays fossiliferous carbonate mound facies. The entire Scotch Grove interval in the Quad Cities is generally non-cherty, but some cherty intervals are locally recognized (Fig. 2). The Scotch Grove Formation becomes notably more chert-rich westward and northwestward from the Quad Cities (Fig. 2). The Scotch Grove is of late Llandoverian to late early or mid Wenlockian age.

The basal member of the Scotch Grove, the Johns Creek Quarry Member, is generally less than 10 feet (3 m) thick, and is characterized by dense sparsely fossiliferous dolomite in the Quad Cities area. It sharply overlies the Hopkinton Formation. The Johns Creek Quarry Member is not always distinguishable, and Welton strata directly overlie the Hopkinton in some sections. The bulk of the Scotch Grove Formation is assigned to the Welton Member, a finely fossil-moldic (primarily crinoidal) dolomite (Figs. 3, 4). The Welton commonly contains articulated crinoid cups (especially *Eucalyptocrinites, Siphonocrinus, Macrostylocrinus, Dimerocrinites*) scattered through the member. Stricklandid and gypidulid brachiopods are often seen in the lower Welton, and nautiloids and trilobites are not uncommon. Welton strata locally extend to the top of the Scotch Grove Formation in the Quad Cities area, and local interbedding with cherty strata (assigned to the Buck Creek Quarry Member elsewhere in eastern Iowa) is seen. At most localities, denser less fossiliferous dolomite strata comprise the upper 25 to 40 feet (7.5-12 m) of the formation, which is assigned to the Waubeek Member (Figs. 3, 4).

Carbonate mound facies of the Palisades-Kepler Member are locally developed in the upper Scotch Grove, which are replaced laterally by inter-mound strata of the Waubeek Member. The extent of this mound (reef) facies in the Quad Cities area is not known with certainty, but upper Scotch Grove mound facies are well displayed in areas to the north and northwest. Mounds of the Palisades-Kepler Member display a central region of fossil-moldic dolomitized mudstones and wackestones, flanked by dipping beds of dolomitized crinoidal wackestones and packstones (Witzke, 1992). There is some potential for confusion in distinguishing carbonate mound facies of the Palisades-Kepler Member from those seen in the younger LeClaire Member (Gower Fm). Lateral and vertical stratigraphic relations serve to distinguish them: the Palisades-Kepler mounds are laterally equivalent to flat-lying strata of the Waubeek Member, whereas the LeClaire mounds laterally interfinger with flat-lying LeClaire and laminated Anamosa strata (see later discussion). In addition, notable faunal differences are seen in the two mound facies, especially in the crinoid and brachiopod faunas. LeClaire and Palisades-Kepler lithologies are generally distinguishable, but where the LeClaire is developed as a

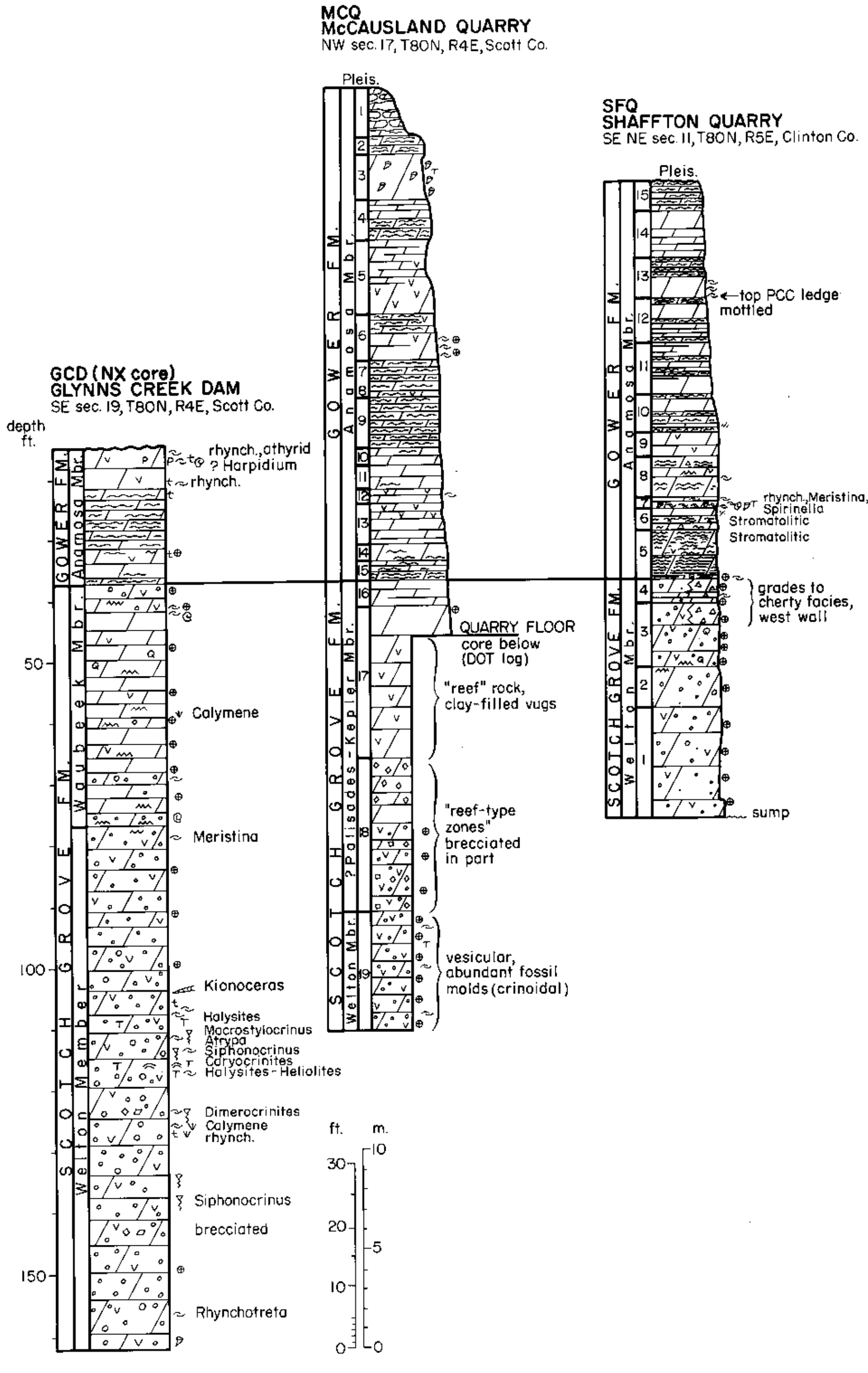

Figure 4. Representative sections of upper Scotch Grove and lower Gower strata in northern Scott and southern Clinton counties, Iowa. Symbols as in Figures 1 and 3. Glynns Creek Dam core is stored at the Iowa DNR-Geological Survey Bureau.

crinoid-rich facies, the two may share many lithic similarities. To further complicate matters, it is likely that some LeClaire mounds are developed on top of pre-existing mounds of the Palisades-Kepler Member. Further subsurface studies are needed in the Quad Cities area to clarify relations between the Scotch Grove and Gower formations, but relationships are clearly displayed in areas to the north and west (see Witzke, 1992).

GOWER STRATIGRAPHY OF QUAD CITIES AREA SILURIAN OUTCROP

Silurian rocks can be visited in the Quad Cities area in roadcuts and quarries (both abandoned and operating). All Silurian exposures within the metropolitan area can reasonably be assigned to the Gower Formation (which is equivalent to the "upper Racine" of Willman, 1973). However, exposures of upper Scotch Grove strata are accessible a short distance north of the Quad Cities in the drainage of the Wapsipinicon River (Fig. 4). The Gower Formation conformably but sharply overlies the upper Scotch Grove, and the base of the formation is drawn below the lowest bed of laminated dolomite. Where the Gower Formation occurs as a non-laminated facies, the lower Gower rocks are generally characterized by unique brachiopod- or coral-bearing lithologies that are laterally equivalent to laminated Gower strata. The Gower Formation reaches thicknesses of over 150 feet (45 m) in the Quad Cities area. Uppermost Gower strata are erosionally beveled, and the formation is unconformably overlain by Middle Devonian carbonates of the Wapsipinicon Group or by Pennsylvanian shale or sandstone strata in the Quad Cities. The Gower Formation is approximately mid-Wenlockian in age at its base, but the age of upper Gower strata is not known with certainty (may be Ludlovian in part).

Anamosa Member

The dominant facies of the Gower Formation is termed the Anamosa Member, which is characterized by flat-lying laminated dolomite. The distinctive laminated strata are interbedded with layers of dense unfossiliferous dolomite, and fossiliferous beds, especially brachiopod- or coral-rich, are locally seen (Fig. 4). The member is named after exposures in Jones Co., Iowa. Although the Anamosa forms the most geographically widespread unit of the Gower Formation in eastern Iowa, Anamosa strata are not particularly well represented in the Quad Cities area, where LeClaire lithologies appear to be relatively more common in outcrop. This pattern may reflect the more resistant nature of LeClaire strata, as well as the greater desirability of LeClaire lithologies for general quarrying purposes. Nevertheless, a notable exposure of the Anamosa Member can be seen in the large quarry at LeClaire, Scott Co., Iowa (Fig. 5).

The Anamosa Member as seen at the LeClaire Quarry differs slightly from Anamosa exposures elsewhere in eastern Iowa in displaying coarser and more faintly developed laminae. It also contains a higher percentage of non-laminated strata, and a faint petroliferous odor is observed in some beds..Laminations varying between planar and crinkly, and some laminated intervals show low amplitude doming suggestive of a subtidal stromatolitic origin (Fig. 5). The eastward extent of Anamosa strata into Illinois is not known with certainty, but the Quad Cities area probably occurs near the eastern limits of the member. Laminated Anamosa strata are known to interbed in a complex manner with the LeClaire Member in the Quad Cities area in both dipping and horizontal strata (as seen in Scott Co., Iowa, and Whiteside and Rock Island Co., Ill.). Complex slump folding of laminated Anamosa strata is locally observed near the margins of some LeClaire build-ups (see photo of quarry near Princeton in Norton, 1899, p. 435). In a general sense, the LeClaire Member represents complex carbonate mound and bank facies, and the laminated Anamosa strata represent intermound and inter-bank facies deposited in slightly deeper water. The absence of a benthic fauna in the laminated Anamosa facies indicates stressed benthic conditions, perhaps due to salinity stratification in the Gower sea (Witzke, 1992).

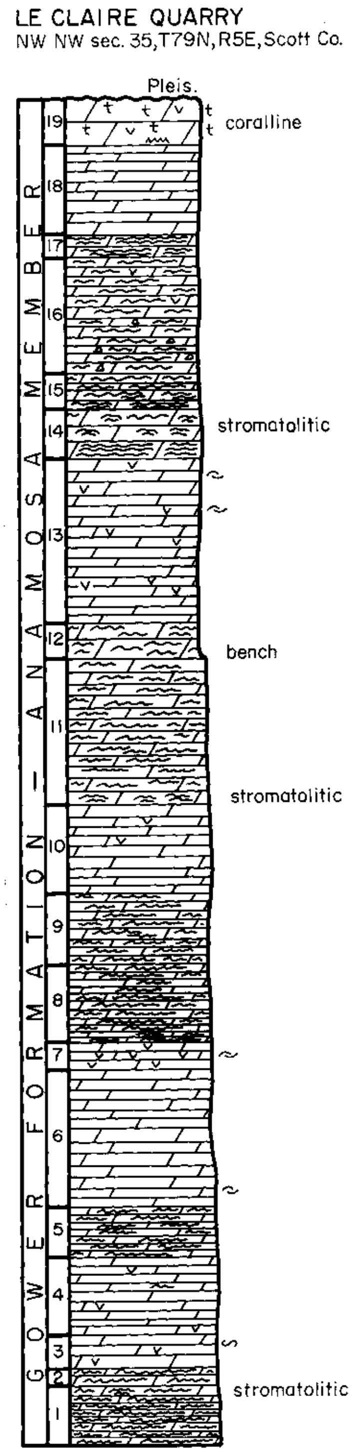

Figure 5. General section of Anamosa Member exposed in the LeClaire Quarry, Scott County, Iowa (after Witzke, 1981). Symbols as in Figure 3. Note that laminated strata (delineated by wavy lines) and non-laminated strata are subequal in cumulative thickness. Total section is 45 m (147 ft) thick.

LeClaire Member

The LeClaire has been used a stratigraphic name for Silurian strata in the Quad Cities areas since 1858 (Hall and Whitney, 1858), and the name has clear stratigraphic precedence over any subsequent term applied to equivalent strata in the area, including the Port Byron and Racine formations. LeClaire facies have been included within the Gower Formation since Norton's (1899) study of Scott County. Originally applied to strata exposed at LeClaire, Scott Co., Iowa, the LeClaire Member will first be characterized in its type occurrence. A series of small exposures can be visited along Cody Road in the town of LeClaire (Fig. 6), and dipping beds indicate a mounded geometry for LeClaire strata between locations 3 and 12. These strata are characterized by porous fossiliferous dolomite containing varying concentrations of low-diversity brachiopod assemblages (especially rhynchonellids and athyrids), scattered tabulate and solitary rugose corals, and an occasional stromatoporoid. Crinoid material is generally absent, but some crinoid debris is recognized at the south end of the mounded area. Brachiopods and pore spaces are commonly coated with bladed and lumpy botryoidal fabrics in the dolomite (symbol "b" on Fig. 6), which are probably relicts of fibrous marine cements deposited within the carbonate mounds during their deposition (Witzke, 1992). Truncation of strata and a reverse in bedding direction at location 3 (Fig. 6) indicate episodic slumping or erosion during sedimentation.

LeClaire strata show a significant lithic and bedding-style change at the south edge of the exposure (locs. 1 and 2, Fig. 6), where strata are horizontally bedded and only sparsely fossiliferous (with scattered small crinoid debris molds). Although the actual transition between mounded LeClaire facies and laminated Anamosa strata is not presently exposed at LeClaire, the LeClaire mounded facies is clearly replaced by horizontally-bedded laminated Anamosa strata only a short distance to the northwest in the large operating quarry (Fig. 6). Coral-bearing units at the top of the quarry (Fig. 5) may represent possible interbedding of LeClaire with Anamosa facies. The relation-

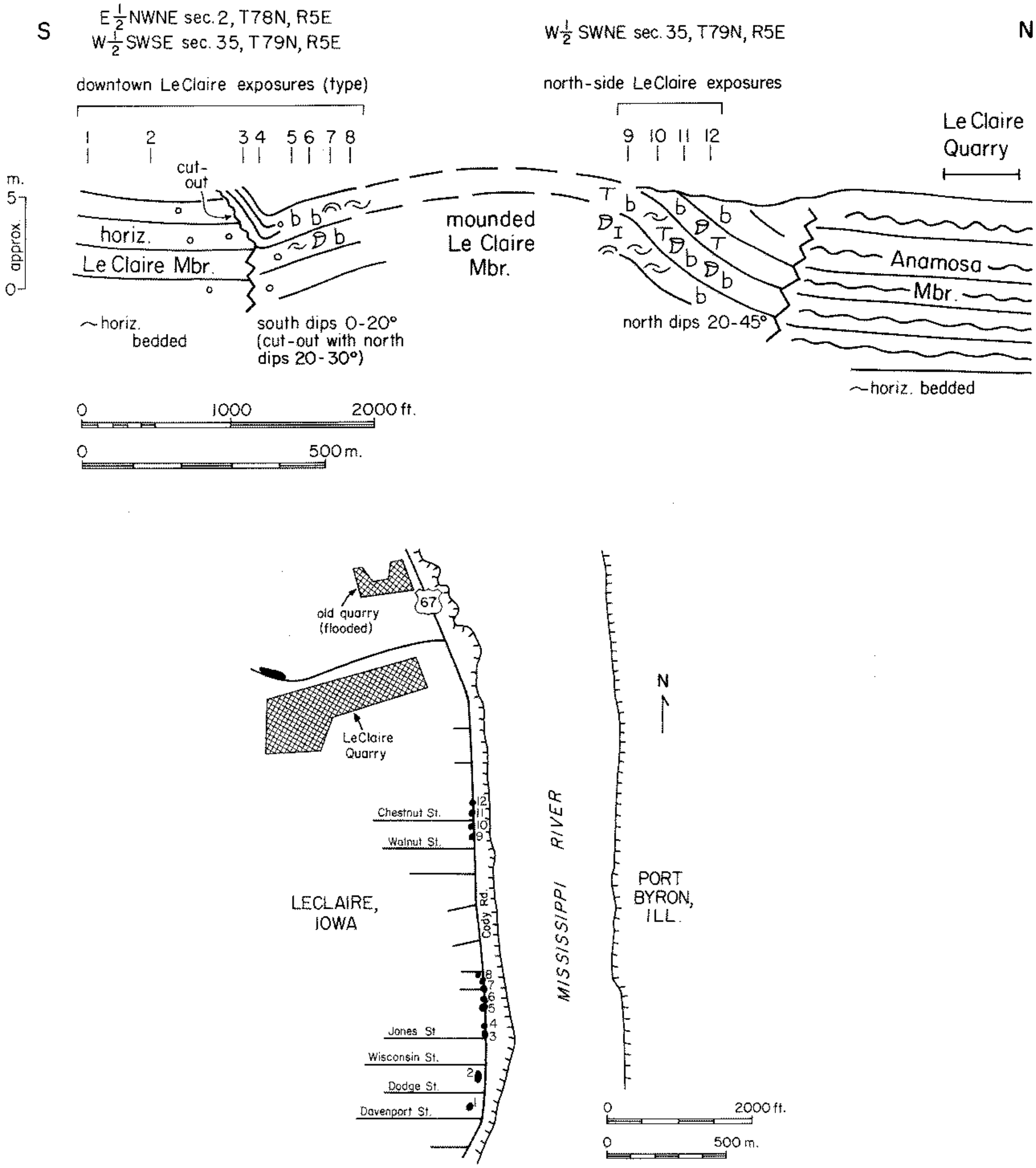

Figure 6. Interpreted stratigraphy displayed at the type locality for the LeClaire Member, Gower Formation. Small-scale exposures (locations 1-12) delimit a mounded feature about 900 m (3000 ft) in diameter, which merges to the south with horizontally-bedded LeClaire strata. To the north, LeClaire facies are replaced by laminated Anamosa strata (see Fig. 5). Symbols as in previous figures; additional symbol "b" (botryoidal coatings and isopachous rims, relict marine cements). Note that the type area for the Port Byron Dolomite lies immediately across the Mississippi River from the type LeClaire section.

ships displayed in the type LeClaire area show that the member 1) occurs as both flat-lying and mounded facies, 2) its fossil content varies laterally (including brachiopod, coral, or crinoidal associations), and 3) is replaced laterally by laminated Anamosa strata.

There are numerous exposures of the LeClaire Member in the Quad Cities area, and individual descriptions of each locality are not attempted here. Instead, a general summary of variations within the member is presented. The LeClaire includes a variety of distinctive dolomite lithologies in both mounded and flat-lying geometries. Fossil-moldic wackestones are generally dominant, which are variably crinoid-, brachiopod-, or coral-rich. Barren to sparse mudstones locally dominate, both in mound and horizontal facies (as at Crow Creek Park, Davenport). Skeletal packstones, variably dominated by crinoid or brachiopod accumulations, are seen in dipping flank strata in some mounds. Vugular porosity is common. Relict marine cements (botryoidal coatings or isopachous rims) and internal sediment fills are seen in many LeClaire mounds, but these are characteristically absent from flat-lying LeClaire strata.

Strata of the LeClaire Member are displayed in a bewildering array of dipping and horizontal beds. Horizontal to low-angle dips (0-10°) characterize most exposures. More pronounced dips (10-45°) occur marginal to LeClaire mounds, and steeply dipping beds are locally observed (to 60°; as at Princeton South roadcut, Witzke, 1992, p. 49). Moderate to steep dips delimit the margins of mounded features (often termed "reefs") in the Quad Cities region (Edmund and Anderson, 1967). However, horizontally-bedded LeClaire strata adjoin these and form the dominant representation of the member in some areas (e.g., the Princeton area, Scott Co.; see Witzke, 1992). The LeClaire mounds display varied geometries, and although difficult to delimit in some exposures, isolated mounds with radially dipping flanks appear to be dominant. The central area of these mounds (often termed "reef cores") are dominated by dolomitized mudstone to skeletal wackestone lithologies with no apparent skeletal framework. Corals, crinoids, nautiloids, and other fossils may be common to abundant (as at the Cordova Quarry, Rock Island Co.). However, at some localities the central mounds are only sparsely fossiliferous, and these were probably constructed primarily of cemented carbonate mud. Flanking strata are variably skeletal-rich to skeletal poor, and graded beds of dolomitized skeletal material are seen at some exposures. Mound flanks are observed to interfinger with laminated Anamosa facies at some localities (e.g., Rock River Quarry, Rock Island Co.; see Anderson et al., 1982, for location).

Horizontal to gently dipping LeClaire strata dominate many exposures, with no apparent mounded or "reefal" geometries. Such strata are observed to interfinger laterally with laminated Anamosa facies and also merge with mounded and more steeply dipping LeClaire facies. The non-mounded LeClaire facies are dominated by non-laminated skeletal mudstone and wackestone dolomite fabrics. The non-mounded facies of the LeClaire have been interpreted as mud-dominated bank facies, which merge in complex geometries with mounded facies to form laterally extensive stratigraphic bodies reaching dimension of up to 2 miles (3.2 km) or more in lateral extent (Witzke, 1992). Such complexes of mound and bank facies, in turn, are known to interfinger with laminated Anamosa strata in low-angle down-dip positions. This indicates that both flat-lying and mounded LeClaire facies occupied a slightly higher depositonal position than the laterally contiguous Anamosa facies. These relationships led Witzke (1987) to propose that Gower deposition occurred within a salinity-stratified embayment, and that the LeClaire stratigraphic bodies formed a partial circulatory barrier to bottom water exchange within the embayment, which lay primarily to the north and west of the present-day Quad Cities area. Diverse stenohaline marine faunas (especially crinoids, trilobites) are found in the LeClaire Member, but fossiliferous Gower mound facies further to the north and west (the Brady Member) contain low-diversity euryhaline faunas (which lack crinoids, trilobites, bryozoans). This provides further evidence of increased surface-water salinities within the Gower embayment.

Although preserved primarily as dolomitized internal and external molds, the LeClaire Member contains a relatively diverse marine fauna, much of which remains unstudied. Brachiopods occur in several associations, commonly with little taxonomic overlap between them. One brachiopod assemblage is generally identified in proximity to, or interfingering with, Anamosa strata, which includes a fauna similar to that seen in the Brady Member to the northwest. Indeterminate rhynchonellids commonly dominate, but protathyrids, *Meristina*, *Nalivkinia* and *Spirinella* are notable. Another assemblage includes large costate pentamerids (*Harpidium*), trimerellids (*Dinobolus, Trimerella*), and a few others (e.g. *Atrypa*). Brachiopods associated with crinoidal LeClaire strata include *Atrypa*, *Harpidium* (noncostate), strophomenids (*Protomegastrophia, Leptaena*, plectodontids), rhynchonellids, protathyrids, spiriferids (*Eospirifer, Hedeina*), and others. Bryozoans are noted, particularly in crinoidal associations. Corals are notable at many LeClaire exposures, and these include a variety of tabulates (*Favosites, Alveolites, Halysites, Syringopora, Heliolites*) and solitary to fasciolate rugosans (*Pycnostylus*, cystiphyllids, zaphrentids, others). Favositids occur in both ramose and massive morphologies. Stromatoporoids are scattered to common in many LeClaire exposures. Ischaditid green alga are occasionally seen in the LeClaire.

A remarkable molluscan fauna is identified in the LeClaire Member. Many gastropods are recognized, including *Naticonema, Euomphalus, Cyclonema, Loxonema, Murchisonia* and the giant *Tremanotus*. Various bivalve taxa also occur, including large megalodonts (generally unknown in the United States Silurian outside of the general Michigan Basin area). A phenomenal diversity of nautiloids has been identified in the LeClaire, and concentrations of nautiloid molds are seen in "pockets" within some of the LeClaire mounds. Foerste (1930) recognized 75 nautiloid species from LeClaire strata at Port Byron. Trilobites are seen in mounded LeClaire facies (see paper by Hickerson in this guidebook), especially *Bumastus* and calymenids. Mikulic (1979) recorded a trilobite accumulation at Cordova that included *Kosovopeltis, Cheirurus*, and *Arctinurus*. Last but not least, an interesting and abundant echinoderm fauna is identified from molds of articulated dorsal cups at some LeClaire mounds. Echinoderm debris is scattered to common at many LeClaire exposures, but this more typical disarticulated material is unidentifiable at finer taxonomic levels. Identified cups include camerate, inadunate, and flexible crinoids, as well as rhombiferan cystoids (*Caryocrinites*). Species of the camerate-like inadunate crinoid *Crotalocrinites* are particularly abundant at Cordova, forming a crinoid association not seen in older Silurian strata of the region. Camerate crinoids are among the most common echinoderms in the LeClaire, and these include common eucalyptocrinitids (*Eucalypt-ocrinites, Calliocrinus*), lampterocrinids (*Siphonocrinus*), dimerocrinitids (*Dimero-crinites*), periechocrinids (*Periechocrinus*), and others. This crinoid assemblage resembles certain associations seen in the older Scotch Grove Formation. However, the LeClaire crinoids include different species of some genera, and distinctive large species of *Periechocrinus*, which are notable in the LeClaire, are absent from the Scotch Grove.

Conodont microfossils have been recovered from the LeClaire (Witzke, 1981, 1992), but sampling has been limited. Recovered taxa from the Quad Cities area include *Panderodus unicostatus, Pseudooneotodus* sp., cf. *Kockelella* sp., and *Ozarkodina* sp., but none of these have proven biostratigraphic utility. Further sampling is encouraged. Significant work remains to be done in the Quad Cities Silurian, including further biostratigraphic refinement (using both conodonts and macrofauna) of the LeClaire, better documentation of LeClaire facies geometries and relationships, more detailed faunal studies, and additional subsurface studies.

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TRILOBITES OF THE SILURIAN RACINE FORMATION OF NORTHWESTERN ILLINOIS

Donald G. Mikulic
Illinois State Geological Survey
615 E. Peabody Dr.
Champaign, Illinois 61820

and

William Hickerson
Department of Geology
Augustana College
Rock Island, Illinois 61201

INTRODUCTION

The trilobite fauna of the Silurian strata in northwestern Illinois is poorly known. Few taxa have been reported or described in the scientific literature, and museum collections from localities in the area contain few trilobite specimens. A preliminary examination of this fauna, however, suggests that a diverse assemblage of trilobites may exist within carbonate buildups of the Racine Formation in the region. These trilobites are allied closely with taxa found in carbonate buildups of the same age in both eastern Iowa and southeastern Wisconsin, but they exhibit little or no similarity to contemporaneous taxa found in similar environments in northeastern Illinois. This paper briefly describes the Racine Formation trilobite fauna from northwestern Illinois and its taphonomic and geographic relationships to similar faunas in the midwestern U. S.

STRATIGRAPHIC SETTING

The lithostratigraphic section of Silurian rocks in northwestern Illinois has been described most recently by Willman (1973) and Willman and Atherton (1975). In summary, the lower 200 feet of the section, consisting of the Mosalem, Tete des Morts, Blanding, Sweeney and Marcus formations, is well exposed in natural outcrops north of the Plum River Fault Zone in Jo Daviess and northern Carroll counties. Based on lithologic and paleontologic characters, these same units can be recognized throughout eastern Iowa (Johnson, 1983; Witzke, 1985, 1992) and, to a limited extent, in the Silurian outliers of southwestern Wisconsin.

An additional 300 feet of younger Silurian strata overlie these units south of the Plum River Fault Zone in Whiteside, Rock Island and Henry counties. These younger strata are poorly exposed in this area, and can be seen only in a few quarries and small outcrops. Willman (1973) and Willman and Atherton (1975) assigned all of the strata overlying the Marcus Formation to the Racine Formation. This included the youngest Silurian rocks in the area, which had previously been named the Port Byron Formation by Savage (1926) in recognition of their distinctive macrofauna.

Unfortunately, the presence of carbonate buildups or buildup-influenced strata in the Racine Formation here led to erroneous correlations with buildup environments in other areas. For example, Worthen (1862) correlated the strata at Port Byron, Rock Island County, with the well-known Bridgeport carbonate buildup in Chicago based on biotic similarities. In reality, however, he was correlating only environmentally similar carbonate buildups, not biostratigraphically correlative fossils.

Buildups within the Racine Formation of northwestern Illinois exhibit important differences in general character and composition among themselves, which may be due, in part, to different stages of buildup development or local variation in environmental conditions. For example, the buildup at Cordova, Rock Island County, contains a highly diverse and abundant echinoderm fauna, whereas the buildups around Port Byron contain the "Port Byron" biota, comprising a distinctive suite of bivalves, brachiopods, gastropods and other fossils. Witzke (1992) recognized several distinct periods of buildup development in the Silurian of eastern Iowa, suggesting that buildups in the Racine Formation of the study area may also represent several different time intervals and not a single period of buildup development.

The distinctive laminated dolomites seen in the Anamosa Member of the Gower Formation in Iowa are conspicuously absent from most of northwestern Illinois. A possible exception is the Anamosa-like strata locally associated with Brady Member-like buildups exposed north of Morrison, Whiteside County (H. A. Lowenstam, 1980, personal communication). This occurrence suggests that strata in at least the upper part of the Racine Formation may be depositionally equivalent to the Gower Formation of eastern Iowa, and it is likely that the Racine is equivalent, or at least closely related to, the upper part of the Hopkinton, the Scotch Grove and the Gower formations of Iowa. Refinement of the Racine portion of the Silurian section in northwestern Illinois awaits the availability of more subsurface data.

RACINE FORMATION TRILOBITES

Very few trilobites have been reported from the Racine Formation of northwestern Illinois. However, examination of the limited museum material available and recent collecting demonstrate that a fairly diverse trilobite fauna exists. Most, if not all, of these trilobites have been collected from carbonate buildups, but they are, in general, rare in these structures. Typically, trilobites are rare in all Silurian buildups, but many more specimens are available from those in northeastern Illinois and southeastern Wisconsin where large fossil collections were assembled over a 150-year period; such collections were not made from the buildups in northwestern Illinois.

Although the number of specimens currently available from the study area is small, there is enough material to establish relationships with trilobite faunas in other Silurian buildups of the midwestern U. S. The buildup trilobites from northwestern Illinois belong to the illaenid-scutelluid-lichid association typical of all normal-marine Ordovician-Devonian carbonate buildups worldwide (Mikulic, 1981). More specifically, they belong to the well-known *Bumastus (Bumastus) ioxus* subassociation (Mikulic, 1979, 1981, in press). This subassociation occurs in Wenlock-Ludlow buildups throughout southeastern Wisconsin, eastern Iowa, western New York and southern Ontario (Mikulic, 1979, 1987, in press) (Fig. 1). It is characterized by the numerical dominance of the bumastine *Bumastus (Bumastus) ioxus* and the scutelluid *Kosovopeltis acamus*. A diversity of other bumastines, cheirurids, lichids and odontopleurids are also present.

In northwestern Illinois, *Bumastus (Bumastus) ioxus* is the most common trilobite in the Racine Formation buildups, and has been found at nearly every locality sampled (Table 1). With the exception of a single proetid specimen, all other trilobite taxa from these buildups are identical to those found in the well-known buildups at Racine and Franklin, Wisconsin. In addition, *Bumastus (Bumastus) ioxus* and *Kosovopeltis acamus* are known from the buildups in the Palisades-Kepler Member of the Scotch Grove Formation at Palisades-Kepler State Park near Cedar Rapids, Linn County, Iowa and at the Wyoming quarry near Wyoming, Jones County, Iowa (Mikulic, 1979).

The occurrence of the *Bumastus (Bumastus) ioxus* subassociation in northwestern Illinois contrasts sharply with the *Bumastus (Cybantyx) insignis* subassociation in the buildups in northeastern Illinois, Indiana and Ohio (Mikulic, 1976, 1979, in press) (Fig. 1). This latter subassociation is also dominated by bumastines, but large and diverse lichids occur with only rare, and generally small,

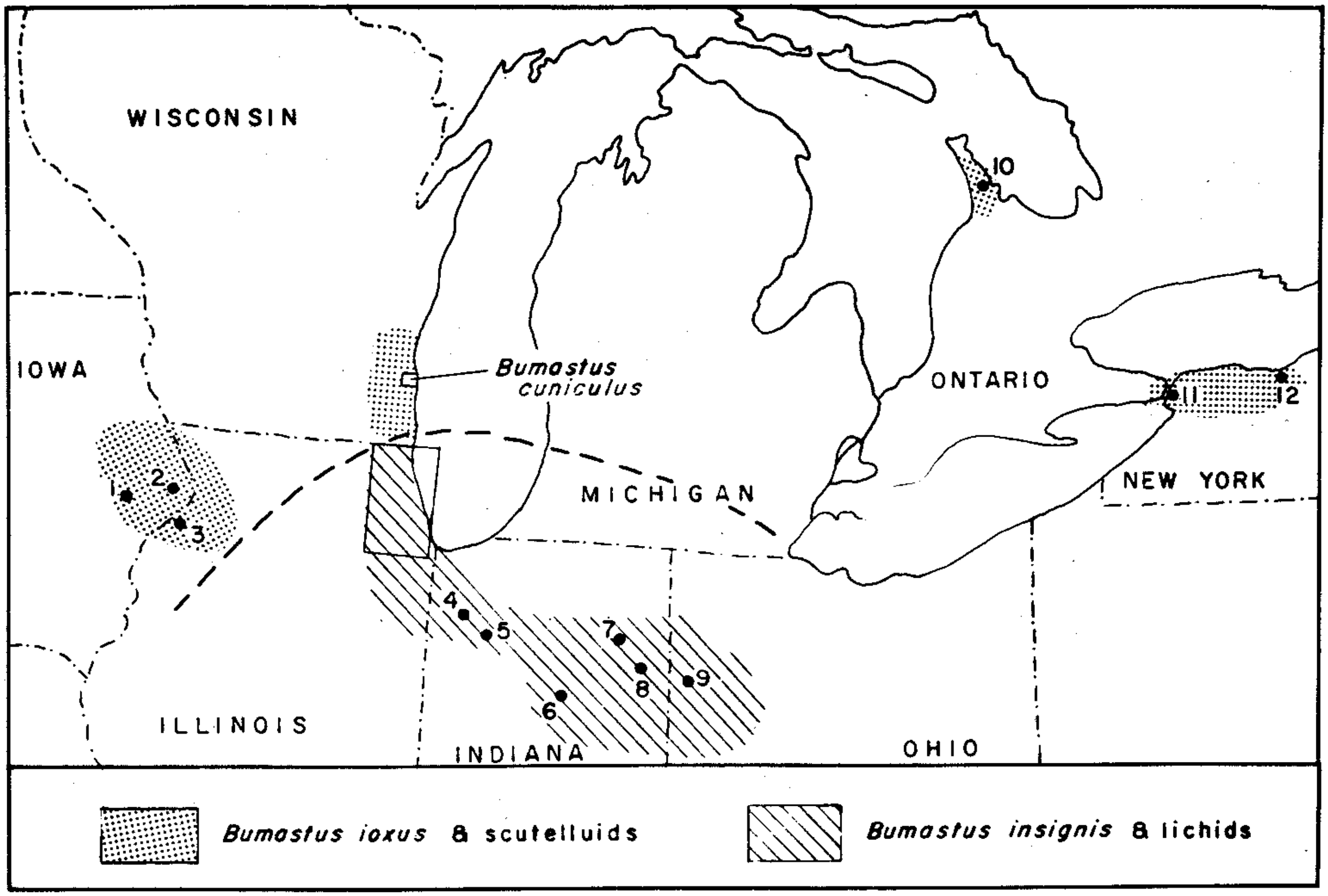

Figure 1. Map showing distribution of carbonate buildups containing the *Bumastus (Bumastus) ioxus* subassociation (stippled) and the *Bumastus (Cybantyx) insignis* subassociation (lined) (from Mikulic, 1979).

scutelluids. On a species level, most of the trilobites are distinct between these two subassociations, even though they contemporaneously occupied the same environment and display nearly identical abundances, distribution and taphonomic features.

Trilobites from the Racine Formation buildups in northwestern Illinois exhibit taphonomic features typical of those in other Silurian buildups. With the exception of *Calymene* sp., which is commonly found articulated, all other trilobite taxa occur as disarticulated skeletal elements. In general, trilobites are rare in buildups, and most specimens are found in conspicuous localized accumulations where disarticulated trilobite molts and dead cephalopods were concentrated in sediment traps (Mikulic, 1976, 1979, 1983; Mikulic and Kluessendorf, 1985). Components of these accumulations usually have a similar size and shape, reflecting hydrodynamic transport and sorting of available skeletal elements. In many cases, these accumulations superficially appear to be monospecific, but some are highly diverse. Hundreds and even thousands of trilobite parts can occur in these accumulations. Most are dominated by nearly equal numbers of *Bumastus (Bumastus) ioxus* cranidia and pygidia, which display a preferred

Table 1. Distribution of trilobites in Racine Formation carbonate buildups in northwestern Illinois.

TAXA	Midway	Cleveland	Allied	Cordova	Morrison	Port Byron	Albany
Bumastus (Bumastus) ioxus	X	X	X	X	X		X
Bumastus (Cybantyx) sp.	X				X		X
Kosovopeltis acamus	X			X	X		X
Arctinurus? sp.	X			X			
Dicranopeltis decipiens	X	X		X			
Calymene sp.	X			X		X	
Cheirurus sp.	X	X	X	X			
proetid	X						

convex-down orientation; free cheeks and other parts are usually underrepresented as a result of the hydrodynamic sorting. The dominance of bumastines in these accumulations probably reflects their true abundance in these buildups. Accumulations dominated by other trilobite taxa or cephalopods are also known. For example, M. Philcox (1972, personal communication) found accumulations of *Kosovopeltis acamus* pygidia in the quarry at Cordova and accumulations of the cephalopod *Phragmoceras* are known from the quarry at Wyoming, Iowa. In addition, Foerste (1930) described a diverse and abundant cephalopod fauna from Port Byron based on specimens collected by T. E. Savage from "pockets" in what are now known to be carbonate buildups, suggesting similar accumulations.

If the accumulations are not viewed as the actual rare, localized features that they are, the concentrated nature and sorting of the trilobites and cephalopods may present a distorted impression of their true diversity and abundance within the buildup. Taxa within these accumulations are the same as those present elsewhere in the buildup. However, the accumulations do not represent living associations, but only artificial associations of bioclasts with similar hydrodynamic properties.

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SILURIAN, DEVONIAN, AND PENNSYLVANIAN TRILOBITES FROM ROCK ISLAND COUNTY, ILLINOIS

William Hickerson
Department of Geology, Augustana College
Rock Island, Illinois

INTRODUCTION

The occurrence of highly fossiliferous carbonate units of Silurian, Devonian, and Pennsylvanian age within Rock Island County offers fossil collectors the unique opportunity of collecting trilobites from all of the above ages in a small geographic area (less than a 30 minute drive from Augustana College). At Allied Stone Quarry (Stop 1) Silurian and Devonian trilobites can be collected at the same locality.

At least 38 species (20 genera) of trilobites have been identified from Rock Island County (Fig. 1). Eleven species (8 genera) are present in the LeClaire Member of the Gower Formation, 16 species (9 genera) are known from the Solon Member of the Little Cedar Formation, 7 species (5 genera) are found in the Rapid Member, Little Cedar Formation, 2 species (2 genera) known from the Cou Falls Member of the Coralville Formation, and 2 species (2 genera) have been collected from the Seville Limestone Member of the Spoon Formation.

TRILOBITES FROM THE SILURIAN GOWER (RACINE) FORMATION

Silurian trilobites are most common in the pelmatozoan-rich facies associated with the mounds of the LeClaire Member at Allied Stone (Stop 1), Midway Stone, and Cleveland Stone quarries, Rock Island County. Styginids (*Bumastus ioxus*, *Bumastus* sp., *Cybantyx*? sp., *Kosovopeltis acamas*), Lichids (*Arctinurus* sp., *Dicranopeltis* sp.), cheirurids (*Cheirurus* 2 sp.), and calymenids (*Calymene niagarensis*) are most common. Proetids (*Proetus*? sp.) and an odontopleurid? are rare (may be under represented in sample due to small size and poor preservation) . This trilobite association appears to be most similar to the trilobite association known from the Racine Formation of southeastern Wisconsin (Donald Mikulic, personal communication). The fauna from Racine, Wisconsin, also includes *B. ioxus*, *K. acamas*, *Arctinurus*, *Dicranopeltis*, *Cybantyx*, *Cheirurus*, and *Proetus*.

The underlying Scotch Grove Formation has a more diverse trilobite fauna, that includes encrinurids and dalmanitids. *Bumastus ioxus* (Pl. 1, fig. F) is by far the most common trilobite present. This species occurs in congregations of hundreds of sclerites, generally cranidia and pygidia, but some accumulations contain large numbers of free cheeks and thoracic segments. *B. ioxus* sclerites are uncommon outside of these accumulations. Articulated material is known for *B. ioxus* and *Calymene niagarensis*, the other species are known from isolated sclerites only.

The rest of the trilobite fauna is uncommon to rare, occurring in facies dominated by pelmatozoans and bryozoans. *Calymene niagarensis* is locally common (Port Byron area) and along with *Dicranopeltis* (Pl. 1, fig. B) and *Cheirurus* (Pl. 1, figs. C, D) have been noted at all localities. One pygidium of *Kosovopeltis acamas* was found amongst a dense *B. ioxus* accumulation and *Proetus*? sp. (Pl. 1, fig. E), *Arctinurus* sp. (Pl. 1, fig. A), *Cybantyx*? (Pl. 1, fig. G) sp., and *Bumastus* sp. are known from Midway Quarry.

TRILOBITES FROM THE MIDDLE DEVONIAN SOLON MEMBER

This is one the most diverse late Middle Devonian trilobite faunas known in North America. Phacopids (*Phacops iowensis iowensis*, *P. rana*?),

SILURIAN

Middle Wenlockian-early Ludlovian?

Gower Formation

LeClaire Member

Bumastus ioxus Hall, 1867
B. sp.
Cybantyx? sp.
Kosovopeltis acamas (Hall, 1865)
Arctinurus sp.
Dicranopeltis sp.
Cheirurus sp. A
Cheirurus sp. B
Calymene niagarensis Hall, 1843
Proetus? sp.
Odontopleurid?

DEVONIAN

Late Givetian

Little Cedar Formation

Solon Member

Phacops iowensis iowensis Delo, 1935
Phacops rana? (Green, 1832)
Neometacanthus sp.
Dechenella? *prouti* (Shumard, 1863)
D.? *elevata* Cooper and Cloud, 1938
D.? *rowi*? (Green, 1838)
D.? sp.
Crassiproetus arietinus (Walter, 1923)
C. sp. A
Proetus? sp.
Cyphaspis sp.
Mystrocephala pulchra (Cooper and Cloud, 1938)
Eudechenella haldemani? (Hall, 1861)
E. sp. A
E.? sp.
Scutellum depressum Cooper and Cloud, 1938

Rapid Member

Phacops norwoodensis (Stumm, 1953)
Greenops sp.
Neometacanthus barrisi (Hall, 1888)
Dechenella? sp. B
Crassiproetus occidens (Hall, 1861)
C. bumastoides (Walter, 1923)
C. sp. B

Coralville Formation

Dechenella? sp. C
Crassiproetus searighti (Walter, 1923)

PENNSYLVANIAN

Early Desmoinesian

Spoon Formation

Seville Limestone Member

Ditomopyge scitula (Meek and Worthen, 1865)
Sevillia trinucleata (Herrick, 1887)

Figure 1. A list of Silurian, Devonian, and Pennsylvanian trilobites from Rock Island County, Illinois.

dalmanitids (*Neometacanthus* sp.), proetids (*Proetus*? sp., *Crassiproetus arietinus*, *C.* sp. A, *Dechenella*? *prouti*, *D.*? *elevata*, *D.*? *rowi*?, *D.*? sp), dechenellids (*Eudechenella*? sp., *Eudechenella haldemani*?, *E.* sp.), aulacopleurids (*Cyphaspis* sp.), brachymetopids (*Mystrocephala pulchra*), and scutelluids (*Scutellum depressum*) are present. In addition, *Dechenella nortoni* and *D.*? sp. A are known from the Solon Member of Johnson and Linn counties, Iowa.

Distribution and relative abundance of this diverse trilobite fauna is strongly facies controlled. *Eudechenella* is the only trilobite present in the most argillaceous lithologies at the base of the Solon Member. The trilobite fauna occurring in the fine-grained, brachiopod-rich calcarenites of the lower half of the member (*Independatrypa independensis* Zone) is dominated by *Phacops iowensis iowensis* (Pl. 2, figs. E, J), *Dechenella*? *elevata* (Pl. 2, fig. G), *Crassiproetus arietinus*, and *Neometacathus* sp. (Pl. 2, fig. I), with lesser numbers of *D.*? *prouti*, *D.*? sp., *C.* sp. A, *Eudechenella* sp., *E.*? sp., *Cyphaspis* sp., and *Scutellum depressum* (Pl. 2, fig. C). *Mystrocephala pulchra* (Pl. 2, fig. K) is restricted to the biostromal facies of the middle part of the member (Lower *profunda* Zone) occurring in association with *D.*? *prouti*, *D.*? *rowi*?, *D.*? *elevata*, *Proetus*? sp., and *C. arietinus*. The upper part of the Solon Member (Upper *profunda* Zone) contains a reduced trilobite fauna consisting of *Phacops rana*?, *D.*? *prouti* (Pl. 2, fig. B), and *Crassiproetus* sp.

Preservation of trilobites from the Solon Member is excellent and complete specimens are known for the majority of the species present. Additionally, monospecific (Pl. 2, fig. G) or mixed species groups of 3-20 specimens are known from 3 horizons in the lower 1 m of the member.

A major trilobite extinction event occurs in the middle Solon member (Taghanic event). *Eudechenella, Dechenella, Scutellum, Cyphaspis, Proetus*?, and *Phacops iowensis* are not known to occur in strata above the *varcus* Zone in North America. Additionally, no Solon Member trilobite species is known from the overlying Rapid Member.

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Plate 1. Silurian and Pennsylvanian trilobites from Rock Island County. A. *Arctinurus* sp. (X 1.2), Midway Q.; B. *Dicranopeltis* sp. (X 2), Midway Q.; C, D. *Cheirurus* sp. A (X 1), Allied Q.; E. *Proetus*? sp. (X 2), Midway Q.; F. *Bumastus ioxus* (X 1), Midway Q.; G. *Cybantyx*? sp. (X 2), Midway Q.; H,I. *Ditomopyge scitula* (X 2), Coal Valley; J. *Sevillia trinucleata* (X 2), Coal Valley.

Plate 2. Devonian (Little Cedar Formation) trilobites from Rock Island County (all X 1 except fig. K is X 2). A. *Crassiproetus occidens*, Lower Rapid Member, Milan Stone Quarry; B. *Dechenella*? *prouti*, Solon Member, Moline; C. *Scutellum depressum*, Solon Member, Iowa City, Iowa.; D. *Dechenella*? sp. B (collected by Jay Woodson, University of Iowa.), Upper Rapid Member, Davenport Cement Company Quarry; E. *Phacops iowensis iowensis* (holotype), Lower Solon Member, Linn County, Iowa.; F. *Phacops norwoodensis*, Lower Rapid Member, Milan Stone Quarry; G. *Dechenella*? *elevata*, Lower Solon Member, Rock Island; H. *Greenops* sp., Lower Rapid Member, Moline; I. *Neometacanthus* sp. (collected by David Sivill), Lower Solon Member, Rock Island; J. *Phacops iowensis iowensis*, Lower Solon Member, Rock Island; K. *Mystrocephala pulchra*, Solon Member, Buffalo, Iowa.

PLATE 1

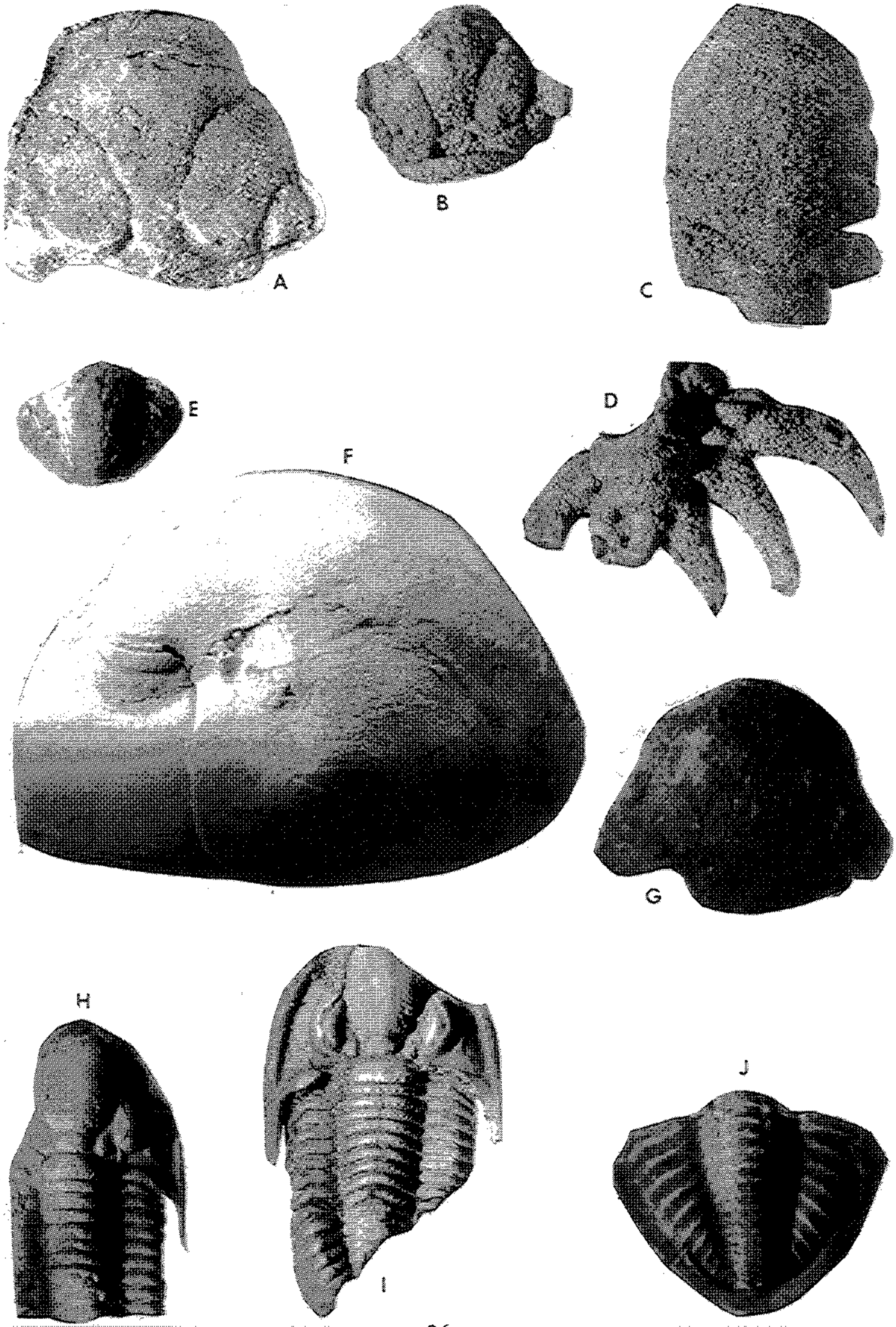
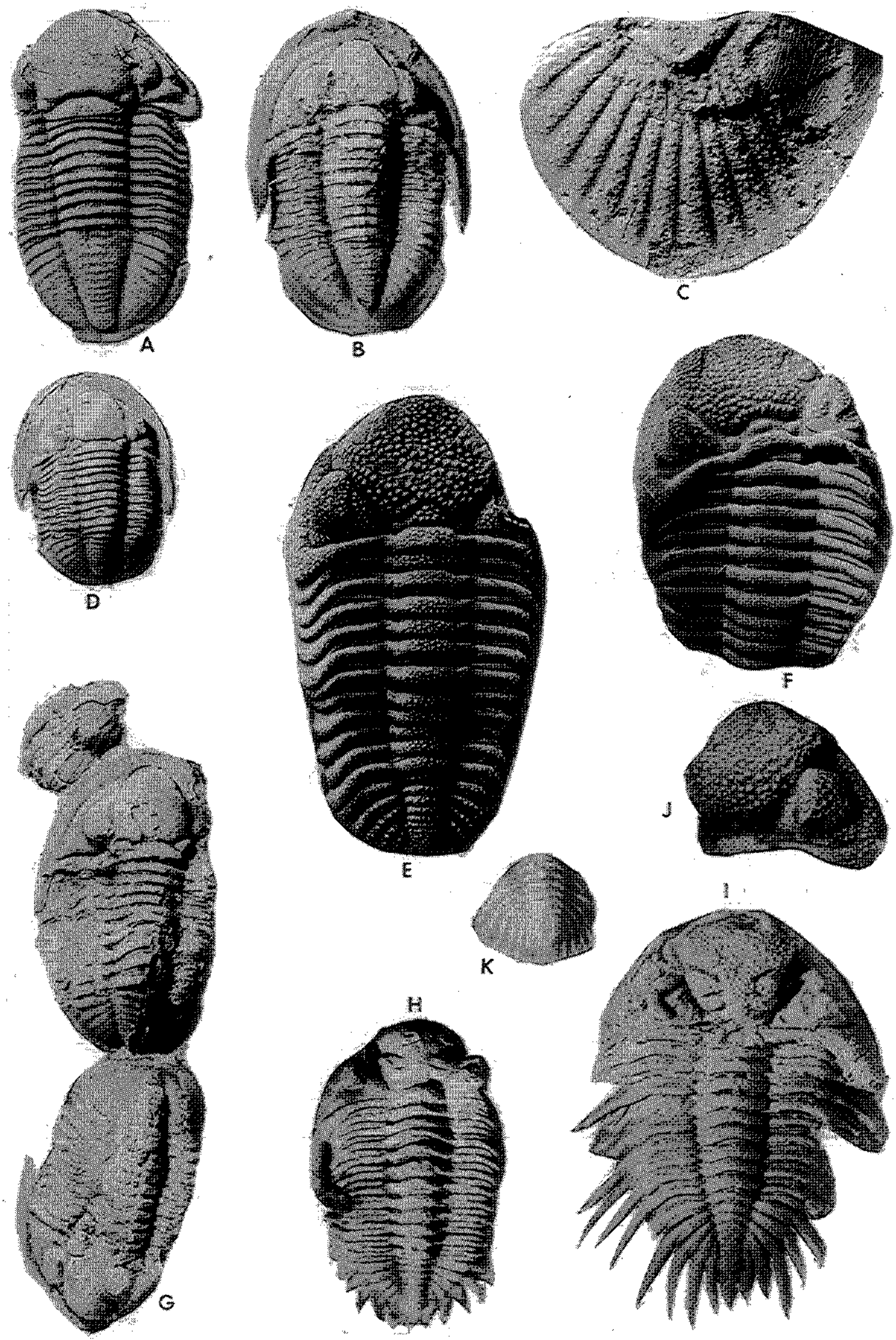


PLATE 2



TRILOBITES FROM THE RAPID MEMBER

Trilobite diversity in the Rapid Member of the Little Cedar Formation is much lower than in the underlying Solon Member The reduced trilobite fauna includes phacopids (*Phacops norwoodensis*, Pl. 2, fig. F), dalmanitids (*Greenops* sp., *Neometacanthus barrisi*), and proetids (*Crassiproetus occidens*, Pl. 2, fig. A; *C. bumastoides*, *C.* sp. B, *Dechenella*? sp. B, Pl. 2, fig. D). This is the last fairly diverse Devonian trilobite fauna known from North America.

The dalmanitids *Greenops* (Pl. 2, fig. H) and *Neometacanthus* are most common in the lower 1/3 of the member and have not been found above the Upper Rapid coral biostrome (*subterminus* Fauna). This is the last occurrence of this highly successful group in North America. *Greenops* and *Neometacanthus* also become extinct in Europe at about the same time (Latest Givetian). Phacopids become increasingly rare in the Upper Rapid Member and have not been noted in the overlying Coralville Formation.

Phacopaceans (*Phacops, Greenops, Neometacanthus*) dominate the trilobite fauna in strata below the Upper Rapid coral biostrome, while proetids (*Crassiproetus, Dechenella*?) dominate the trilobite fauna above the biostrome.

Preservation of Rapid trilobites is generally quite good and complete specimens are known for all the species. Complete specimens and monospecific or mixed species groups are particularly common in the basal 1 m of the member. Many beautiful specimens have been collected from the Basal Rapid Member at Allied Stone Quarry (Stop 1), Milan Stone Quarry (Stop 2), and at the Davenport Cement Company Quarry (Stop 3). Complete specimens from the Upper Rapid Member are rare, less than 15 have been collected over the years and all were found at Stop 3.

TRILOBITES FROM THE CORALVILLE FORMATION

The Coralville Formation is not well exposed in Rock Island County, but is well exposed across the Mississippi River in the Buffalo, Iowa, area. Only two proetids (*Crassiproetus searighti, Dechenella*? sp. C) are known from this area. In addition, *Mystrocephala raripustulosa* is known from the type section of the Cou Falls Member at North Liberty, Iowa.

Trilobites are not known from Devonian strata above the Cou Falls, with the exceptions of one cranidium of *Harpidella*? *brandonensis* from the "Independence" Shale and a cranidium and pygidium of a scutelluid (*Scutellum*? *thomasi*) from the upper part of the Lime Creek Formation in northern Iowa. Thus, there is a gap in the midcontinent trilobite record that spans the latest Givetian and Frasnian. It is interesting to note that the three genera (*Crassiproetus, Dechenella*?, *Mystrocephala*) surviving into the Coralville Formation are endemics, restricted to North America throughout their evolutionary history. Little Cedar Formation trilobites *Phacops rana/norwoodensis*, *Greenops*, *Neometacanthus*, *Scutellum*, *Eudechenella*, *Dechenella*, *Cyphaspis*, and *Proetus* migrated to North America during the early Middle Devonian from Europe and North Africa.

TRILOBITES FROM THE PENNSYLVANIAN SPOON FORMATION

The "Seville" Limestone Member of the Spoon Formation is well exposed in and around the village of Coal Valley, Illinois. This dark gray to black limestone contains a highly diverse marine fauna. The fauna is dominated by brachiopods (productids) and mollusks (bivalves, gastropods, nautiloids) with common trilobites (*Ditomopyge scitula, Sevilia trinucleata*) and a variety of fish teeth.

Ditomopyge and *Sevillia* are present throughout eastern North America in rocks of Early Desmoinesian age. Many complete individuals, as well as groups of *Ditomopyge scitula* have been collected from the Coal Valley area. *Sevillia trinucleata* occurs rarely, only 3 pygidia and 1 cranidium were collected by the author as opposed to nearly 100 specimens of *Ditomopyge* (including many complete specimens). A complete specimen of *Sevillia trinucleata* was collected by Tom Walsh of Coal Valley. This specimen is possibly the only complete exoskeleton of this species known from North America.

THE MIDDLE DEVONIAN (LATE EIFELIAN-EARLY GIVETIAN) BRACHIOPOD FAUNA OF THE WAPSIPINICON GROUP OF EASTERN IOWA AND NORTHWESTERN ILLINOIS

Jed Day
Department of Geography-Geology
Illinois State University
Normal, Illinois 69790-4400

and

William F. Koch
Department of Zoology
Oregon State University
Corvallis, Oregon 97331

INTRODUCTION

In this paper we present preliminary results of our investigations of the older brachiopod faunas from the Devonian succession in the Iowa Basin (Fig. 1). Recent sampling of the Spillville Formation in its type area, and the Otis Formation in east-central Iowa and the Moline-Rock Island area of northwestern Illinois, have produced a brachiopod fauna consisting of at least twenty species of brachiopods (Table 1). One species of *Emanuella* occurs in the Otis Formation of east-central and southeastern Iowa and northwestern Illinois. At least nineteen brachiopod species occur in the strata of the Spillville Formation in northeastern Iowa. The Spillville and Otis faunas contain widespread species that occur in coeval strata in central and western Canada, the Michigan Basin (Wisconsin and Michigan), the Moose River Basin (Ontario), and the Appalachian Basin (New York).

Brachiopod faunas of the Cedar Valley Group have been extensively documented in dozens of older stratigraphic and paleontologic studies dating to the 1840's (summaries in Day, 1989a, 1989b, 1992). Although known for nearly one hundred years, brachiopod faunas from strata now included in the Spillville and Otis formations (Figs. 1 and 2) have been largely overlooked. Renewed interest in the older Devonian rocks in Iowa was prompted by documentation of late Eifelian-early Givetian age conodont faunas from the Spillville and Otis formations by Klapper and Barrick in 1983. Stratigraphic and biostratigraphic studies of these units published since Klapper and Barrick's conodont study include: Bunker et al. (1983), Witzke and Bunker (1984), Bunker et al. (1985), Witzke et al. (1985), Witzke et al. (1989), Bunker and Witzke (1992), Johnson and Klapper (1992), Day and Koch (1994), Day et al. (Fig. 3; *in press*).

Previous Studies of Spillville-Otis Brachiopod Faunas

Brachiopods from strata now included in the Spillville and Otis formations of Iowa have been mentioned in studies dating to the 1890's. Norton (1894, 1895, 1901, 1920) identified "*Spirifer subumbonus*" HALL (= *Emanuella*) from strata now included in the Coggon and Cedar Rapids members of the Otis Formation from Linn County in east-central Iowa. More recent reports of *Emanuella* from the Otis are discussed in various studies by Bunker et al. (1985), Witzke et al. (1985), and Witzke et al. (1989).

In Calvin's (1903) account of the Devonian stratigraphy and paleontology in Howard County

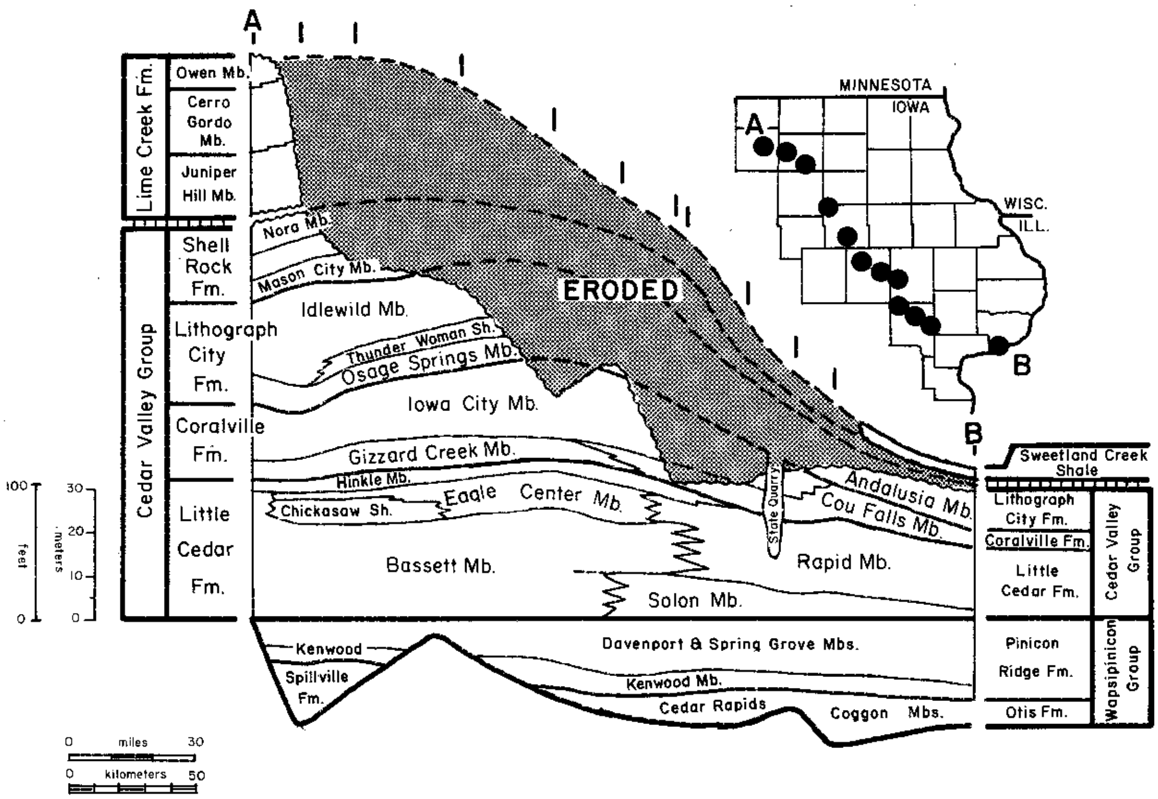


Figure 1. Cross-section of the late Eifelian-Frasnian strata of north-central and eastern Iowa (modified from: fig. 1 of Witzke et al., 1989; fig. 3 of Bunker and Witzke, 1992; fig. 2 of Day, 1992).

(1903) he coined the term "Productella Beds" to refer to dolomites of the lower two thirds the Spillville containing moldic megafossils that included: *Stropheodonta demissa, Productella subalata, Spirifer pennatus, Cyrtina hamiltonensis,* and *Spirifer subumbonus*. The same fauna, including atrypids, was reported from the Spillville in what is now its type area in Winneshiek County by Calvin (1906, p. 113-116). The occurrence of "Productella" in the Spillville mentioned by Calvin (ibid.) and Witzke et al. (1983; 1989) probably corresponds to occurrences of either, *Spinulicosta* in the lower part, or more likely, the abundant medium-sized productellid (undescribed genus) in the middle-upper part of the Spillville in its type area (Fig. 4, Table 1). Cooper (1968) later placed the ambocoelids known from the Otis in *Emanuella*.

Recent reports discussing aspects of the Spillville fauna include Bunker et al. (1983), Witzke and Bunker (1984), and Witzke et al. (1989), and Day and Koch (1994). Day and Koch (1994) listed species identified from the Spillville in its type area, and defined two informal faunal intervals or brachiopod biozones termed the *Spinulicosta-Spinatrypa* and *Spinatrypina-Brachyspirifer*? faunas in the lower and upper part of the Spillville, respectively.

Paleobiogeographic Significance and Affinities of the Spillville-Otis Brachiopod Faunas

The brachiopods identified from the Spillville and Otis formations (Table 1, Fig. 4) provide

Table 1. Brachiopod fauna of the lower part of the Wapsipinicon Group now known from: PART A. the Spillville Formation of northern Iowa and southern Minnesota; PART B. from the Coggon and Cedar Rapids members of the Otis Formation in central and eastern Iowa, and western Illinois.

PART A. BRACHIOPOD FAUNA OF THE SPILLVILLE FM.

Class INARTICULATA
Petrocrania n.sp.

Class ARTICULATA
Order ORTHIDA
Schizophoria sp.

Order PENTAMERIDA
Gypidula n.sp.

Order TEREBRATULIDA
Cranaena sp.

Order STROPHOMENIDA
Strophodonta (Strophodonta) n.sp.
Devonochonetes? sp.
Schuchertella sp. or *Eoschuchertella* sp.
New productellid genus (with costellate brachial valve)
Spinulicosta cf. *S. spinulicosta* (HALL)

Order SPIRIFERIDA
Carinatrypa dysmorphostrota (WARREN, 1944)
Spinatrypa (Isospinatrypa) borealis (WARREN, 1944)
Spinatrypina (S.) aff. *S. (S.) edmundsi* COPPER, 1978
Variatrypa (Variatrypa) arctica (WARREN, 1944)
Cyrtina cf. *C. hamiltonensis* (HALL)
Brachyspirifer? sp.
Emanuella meristoides (MEEK, 1867)
Emanuella cf. *E.* sp. II of Caldwell, 1968.
Warrenella (Warrenillina) cf. *W. (W.) extensa* BRICE, 1982

PART B: BRACHIOPOD FAUNA OF THE OTIS FM.

Emanuella sublineata (MEEK, 1867)
E. cf. *E. sublineata* (MEEK, 1867)

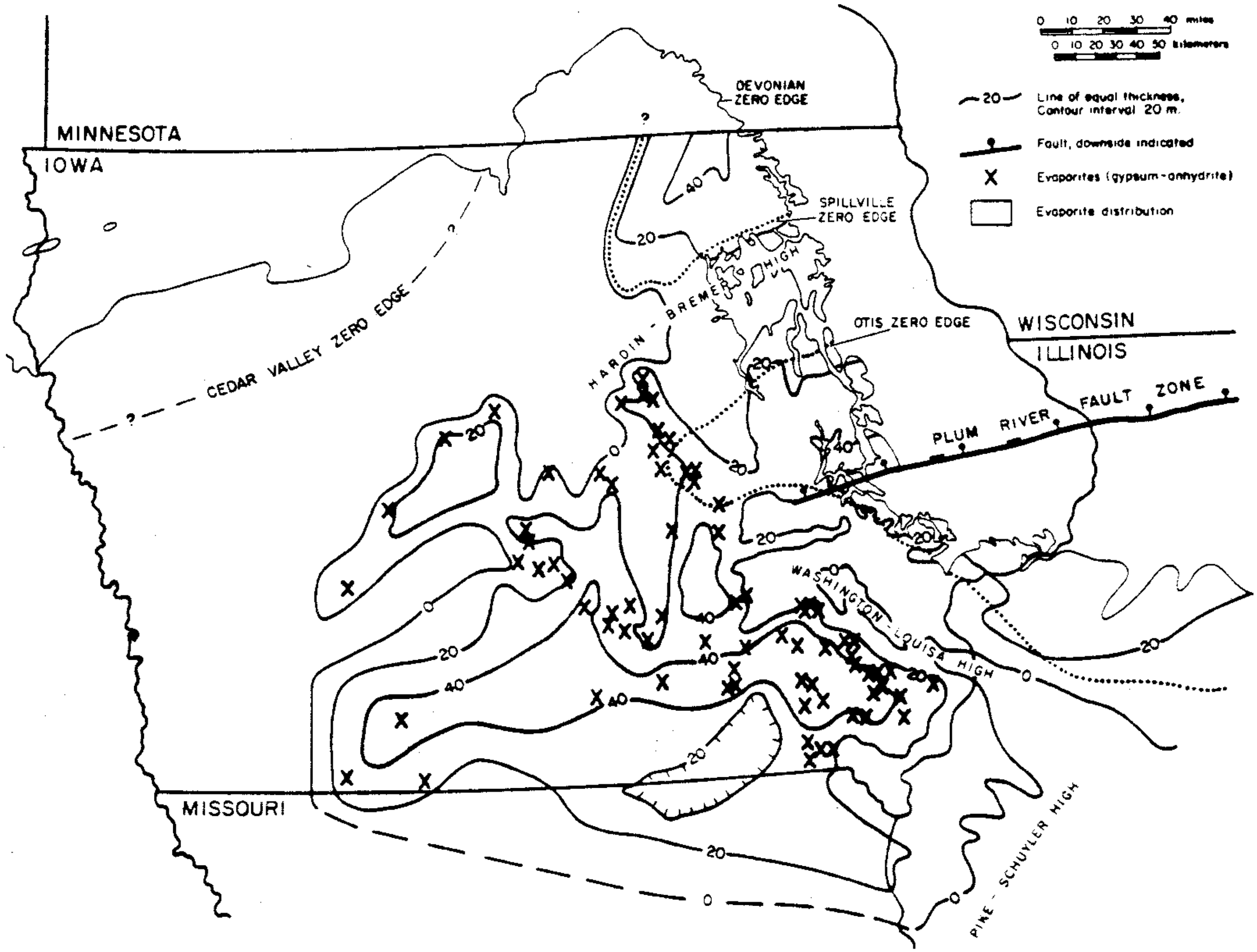


Figure 2. Isopach and evaporite distribution map of the Wapsipinicon Group in the Iowa Basin showing the distribution of the Spillville Formation in northeastern Iowa and the emergent Silurian bedrock structure known as the Hardin-Bremer High. The Otis Formation occurs in the region south and southwest of the Hardin-Bremer High (from Witzke et al., 1989; Bunker and Witzke, 1992).

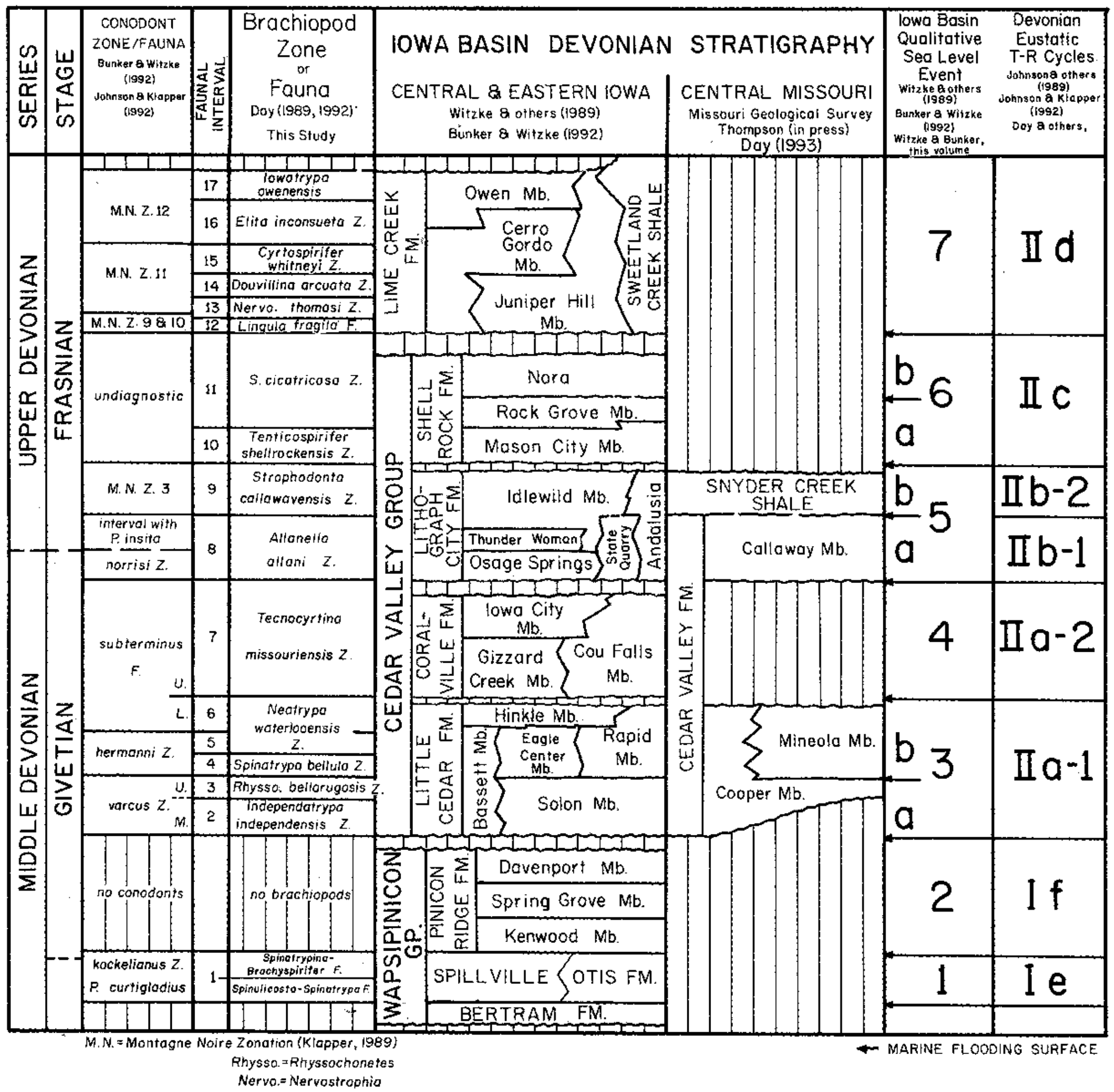


Figure 3. Stratigraphic and biostratigraphic framework for the Middle-Early Upper Devonian strata of the Iowa Basin (after Day, *in press*) including central Missouri, showing relationships between the Iowa Devonian sea-level curve (from Witzke et al., 1989; Bunker and Witzke, 1992; and Witzke and Bunker, *in press*) and the Devonian eustatic curve (from Johnson et al., 1985; Johnson and Klapper, 1992; Day et al., *in press*). The *Spinulicosta-Spinatrypa* and *Spinatrypina-Brachyspirifer*? faunas are defined herein based on preliminary brachiopod sequence documented in the Spillville Formation (Fig. 4). New Frasnian conodont zonation of the Sweetland Creek from Klapper (in Johnson and Klapper, 1992). Brachiopod biostratigraphy for the Cedar Valley Group and Lime Creek Formation from Day (1989a, 1992, *in press*), and Day and Koch (1994).

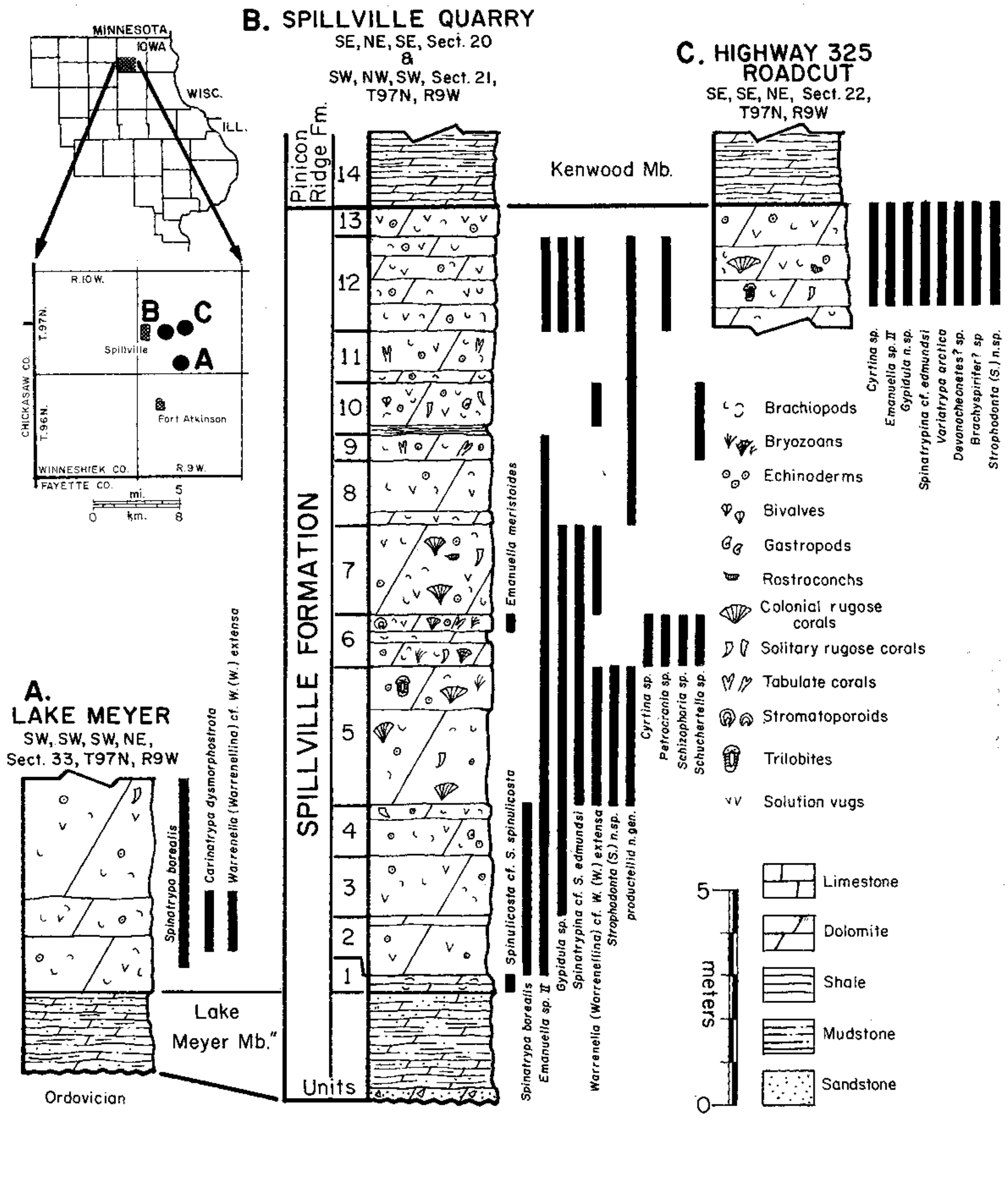


Figure 4. Distribution of brachiopod species and stratigraphy of the Spillville Formation at localities in Winneshiek County in north-eastern Iowa. The type section of the Spillville is the Spillville Quarry (Locality B) as designated by Klapper and Barrick (1983). The *Spinulicosta-Spinatrypa* Fauna is defined on the species recovered in assemblages from units 1-4 at the Spillville Quarry (Locality B) and in the lower Spillville at the Lake Meyer County Park section (Locality A). Brachiopods of the *Spinatrypina-Brachyspirifer* Fauna make up assemblages in units 5-13 at the Spillville Quarry and the entire upper part of the Spillville exposed at the High 325 roadcut section (Locality C).

evidence for open-marine connections between northern Iowa and central and western Canadian cratonic shelf areas of the southeastern (Saskatchewan-southern Manitoba) and northeastern Elk Point basins (southern Northwest Territories and northeastern Alberta). Nearly half of the species in Spillville-Otis fauna migrated into Iowa from these low latitude Old World Realm (OWR) shelf areas of western North America. Important OWR migrants include species of: *Emanuella*, forms identified here as *Warrenella* (*Warrenellina*), *Spinatrypa* (*Isospinatrypa*), *Carinatrypa*, *Spinatrypina* (*Spinatrypina*), and *Gypidula*. Old World Realm *Emanuella* occurs in shallow platform facies and may be a different genus from eastern North American (EAR) forms which occur in outer shelf facies in the Appalachian Basin. Other elements of the Spillville fauna with affinities with Michigan Basin faunas (Eastern Americas Realm [EAR]) include: *Strophodonta* (*S.*), *Meristina*, *Devonochonetes*, and probably *Cyrtina*. At least four species appear to be endemic to the Spillville shelf in northern Iowa and southeastern Minnesota.

Migrations of brachiopods derived from OWR shelf areas into central and eastern North America, through the seaway connection along the northern part of Iowa Basin, were made possible by the development of subtidal conditions across the Transcontinental Arch as a consequence of a major transgression that began in the late Eifelian. The deepening event that initiated Spillville and Otis sedimentation in Iowa and Minnesota corresponds to Euramerican Devonian T-R cycle Ie (Johnson et al., 1985; Witzke et al., 1989; Bunker and Witzke, 1992; Johnson and Klapper, 1992; Day et al. *in press*; Day, *in press*). The widespread dispersal of tropical OWR taxa into central and eastern North American at this time signifies a breakdown of brachiopod provincialism that characterized the Lower Devonian, early-mid Eifelian, and the early-middle Givetian (Johnson, 1970, 1971; Johnson and Boucot, 1973).

This transgression established open-marine conditions in northeastern Iowa and southern Minnesota where strata of the Spillville accumulated. The southern part of the Iowa Basin was physically isolated from the northern open-marine Spillville shelf by the emergent Hardin-Bremer High (Bunker et al., 1983; Witzke et al. 1989), and restricted-marine conditions prevailed in the region where strata of the Otis accumulated (Fig. 2). The restricted-marine Otis shelf area probably had connections with deeper open-marine shelf areas of the Illinois Basin to the east and southeast, versus directly to the north with the Spillville shelf area. Equivalents of the Spillville and Otis in the Illinois Basin are thought to include part of the Saint Laurent Limestone of southern Illinois and southeastern Missouri, based on brachiopods listed in Fraunfelter and Baesemann (1972).

BRACHIOPOD FAUNA OF THE OTIS FORMATION

Thus far, only species of the ambocoelid brachiopod *Emanuella* are known to occur in the Otis formation of Iowa. The low-diversity brachiopod assemblages of the Otis are here designated as the *Emanuella* Fauna. In east-central and eastern Iowa, the Otis Formation is divided into a lower dolomitic Coggon, and an upper limestone-dominated Cedar Rapids members (Bunker et al., 1985. p. 44-46; Witzke et al., 1989). *Emanuella* has been reported from both the Coggon and Cedar Rapids members (Bunker et al., 1985; and Witzke et al., 1989). Samples taken by Brian Witzke and Bill Bunker (Iowa Geological Survey Bureau) from exposures of the Coggon Member at the Cedar Valley Quarry in Cedar County contain abundant moldic specimens of *Emanuella sublineata* (MEEK, 1867). In Scott County in southeastern Iowa and Rock Island County in northwestern Illinois, the Otis is not divided into members (Witzke et al., 1985). One of us (J.D.) recently sampled the Otis Formation (undifferentiated) at the Allied Quarry in Rock Island Illinois. There the Otis contains scattered but abundant specimens of *Emanuella* cf. *E. sublineata* (MEEK, 1867).

Related species of *Emanuella* occur in the Spillville Formation of northeastern Iowa (Fig. 4). There, *E.* sp. II of Caldwell (1967) first occurs in the lower part, and ranges through most of the

Spillville. Rare *E. meristoides* (MEEK, 1867) have been recovered from the middle-upper parts of the Spillville in the interval of the *Spinatrypina-Brachyspirifer*? Fauna of Day and Koch (1994).

BRACHIOPOD FAUNA OF THE SPILLVILLE FORMATION

The composition of the brachiopod fauna recovered thus far from the Spillville Formation in its type area is shown in Table 1 (part A) and Figure 4. In parts of Winneshiek, Howard, Chickasaw, and Floyd counties, the basal few meters of the Spillville is clastic-rich and largely devoid of megafossils. This basal interval was informally termed the "Lake Meyer member" by Bunker et al. (1983). Thus far the Lake Meyer strata have not yielded a brachiopod fauna. The fauna listed in Table 1 (part A) is restricted to the fossiliferous skeletal dolomites above the basal Lake Meyer clastics.

Calvin (1903) described the lower forty feet (12.2 m) of the Spillville as the "Productella beds", consisting of massive vesicular dolomite featuring fossil molds. Calvin described the upper 15 feet (4.5 m) as the "calcite-bearing beds" consisting of bedded dolomite featuring "included masses of calcite". These subdivisions can be recognized in the type area as shown by Bunker et al. (1983) and discussed in Witzke and Bunker (1984). The upper calcite-bearing beds" of Calvin (1903) are of interest since the large masses of calcite consist mostly of cement void fillings of large skeletal molds (some secondarily enlarged by solution) of colonial rugose and tabulate corals, or hemispherical stromatoporoids. A number of brachiopods (*Gypidula* n.sp., *Spinatrypina edmundsi*, and *Emanuella* sp. II) occur in association with corals and stromatoporoids in the middle-upper parts of the Spillville.

Day and Koch (1994) outlined a preliminary brachiopod sequence in the Spillville in northern Iowa. The brachiopod fauna in the lower part of the Spillville was designated by Day and Koch (1994) as the *Spinulicosta-Spinatrypa* Fauna, and the *Spinatrypina-Brachyspirifer*? Fauna includes the diverse brachiopod fauna of the upper Spillville.

Spinulicosta-Spinatrypa Fauna

The oldest elements of the Spillville brachiopod fauna are assigned to the late Eifelian-early Givetian age *Spinulicosta-Spinatrypa* Fauna (Day and Koch, 1994). Elements of this fauna first appear in the lower part of the Spillville Formation in its type area in Winneshiek County in north-eastern Iowa (Fig. 4, units 1-4 at the Spillville Quarry), and serve to characterize lower part of Faunal Interval 1 of the Iowa Devonian composite faunal sequence (Fig. 3). Species occurring in this fauna include: *Spinulicosta spinulicosta* (HALL), *Emanuella* sp. II of Caldwell (1967), *Gypidula* n.sp., *Spinatrypa* (*Isospinatrypa*) cf. *S.* (*I.*) *borealis* (WARREN), *Carinatrypa dysmorphostrota* (CRICKMAY, 1960), and *Warrenella* (*Warrenellina*) sp. cf. *W.* (*W.*) *extensa* BRICE (1982).

Brice (1982) described *W.* (*W.*) *extensa* from the middle part of Blue Fiord Formation of the Canadian Arctic Islands. A similar form described as *Undispirifer* sp. by Johnson (1974, pl. 10, figs. 9-15; 1990, fig. 49, F.I. 19-21) occurs in early Givetian strata in central Nevada. This is one of the oldest known representatives of *Warrenella* from central North America. *Warrenella* maya (originally cited as "*Martinia*" *maya*, Billings, 1860) occurs in the Delaware Limestone of central Ohio (Stauffer, 1910). Its occurrence in Iowa and Ohio indicates that migrations were possible from equatorial seaway areas of the Canadian Arctic Islands during initial stages of Devonian T-R cycle Ie (Johnson et al., 1985; Johnson and Klapper, 1992; Day et al., *in press*).

Of significance is the occurrence of *Carinatrypa dysmorphostrota* (CRICKMAY, 1960) in association with *Spinatrypa borealis* (WARREN, 1944) in the lower part of the Spillville Formation at the Lake Meyer County Park section (Fig. 4). Crickmay (1960) originally described "*Spinatrypa*" *dysmorphostrota* from strata of the Hume Formation assigned to his "*verrilli* zone" in the Mackenzie River Valley in the Northwest Territories (N.W.T.). Norris (1968) and Caldwell (1971) referred to the brachiopod fauna in the middle-upper part of the

Hume in this region as the *Spinulicosta stainbrooki* fauna. This interval was later designated as the *dysmorphostrota* Zone by Pedder (1975). The composition of the Spillville brachiopod fauna indicates a direct correlation with the *dysmorphostrota* Zone (Pedder, 1975) of the Hume in the Mackenzie River Valley in the N.W.T.

Copper (1973) designated *Spinatrypa dysmorphostrota* CRICKMAY as the genotype of *Carinatrypa*, and described additional species in 1978. In Michigan, *Carinatrypa dysmorphostrota* is illustrated from the lower part of the Rogers City Limestone by Ehlers and Kesling (1970). The related species (*C. sinuata*) occurs in the western part of the Michigan Basin in the Lake Church Formation of southern Wisconsin (Cleland, 1911; Griesemer, 1965; Copper, 1973).

Spinatrypina-Brachyspirifer? Fauna

The remainder of the Spillville fauna (Fig. 4, units 5-12 at the Spillville Quarry, and Highway 325 roadcut section) is included in the *Spinatrypina-Brachyspirifer*? Fauna. Members of this fauna include: *Spinatrypina* (*Spinatrypina*) *edmundsi* COPPER (1978), *Gypidula* n.sp., *Schizophoria* sp., *Spinatrypa* (*I.*) *borealis* (WARREN), *Schuchertella* sp., *Devonochonetes*? sp., *Emanuella*. sp. II of Caldwell (1967), *E. meristoides* (MEEK, 1867), *Strophodonta* (*Strophodonta*) n.sp. aff. *S.* (*S.*) *homolostriata* (GRABAU, 1910), *Cyrtina* sp., *Cranaena* sp., *Variatrypa* (*Variatrypa*) *arctica* (WARREN, 1944), a new genus of productellid (with a costellate brachial valve and otherwise similar to *Productella*), and a medium-size alate spiriferid identical to the form identified as *Brachyspirifer* sp. from the Rogers City Limestone of Michigan (Ehlers and Kesling, 1970, Pl. 12, figs. 44-48). The same species occurs in the Lake Church Formation of southeastern Wisconsin (collections of Koch and Day). A similar, but more alate form (*B. ventroplicatus*) was described by Cooper (1945) from St. Laurent Limestone of eastern Missouri.

DISCUSSION

Important aspects of the brachiopod faunas now known from the Spillville and Otis formations involve the timing of appearances of atrypid and ambocoelid brachiopods. Important range inceptions in the interval of the *Spinulicosta-Spinatrypa* Fauna in the lower part of the Spillville include: the atrypids *Carinatrypa dysmorphostrota* and *Spinatrypa* (*Isospinatrypa*) *borealis* and the ambocoelid *Emanuella* sp. II of Caldwell (1967). *Emanuella sublineata* also appears to enter the Iowa Basin at this time as recorded by its occurrence in the Coggon Member of the Otis Formation in central and eastern Iowa, and the Otis in the Rock Island area of northwestern Illinois. Subsequently *Spinatrypina* (*S.*) *edmundsi*, *Variatrypa* (*V.*) *arctica*, *Emanuella meristoides*, and *Brachyspirifer*? sp. appear in the interval of the *Spinatrypina-Brachyspirifer*? Fauna of the upper part of the Spillville (Fig. 4). A closely similar fauna displaying a very similar pattern of brachiopod occurrences and range inceptions is seen in the *Emanuella* and *Omphalocirrus* zones of the Rogers City Limestone of Michigan first outlined by Ehlers and Kesling (1970). The proposed correlations of the Spillville and Rogers City faunal intervals are shown in Figure 5.

The occurrences of the atrypids *Carinatrypa dysmorphostrota* (WARREN) and *Spinatrypa* (*Isospinatrypa*) *borealis*, with *Emanuella* sp. II of Caldwell (1967), *E. sublineata E. meristoides* (MEEK), and *Gypidula* n.sp. also indicate direct faunal communications with western and central Canadian carbonate platform faunas. The same atrypids, emanuellids, and a related species of *Gypidula* were illustrated (Crickmay, 1960; Caldwell, 1971) from the Hume Formation in the Lower Mackenzie River Valley of the southern Northwest Territories (N.W.T.).

Brachiopod and conodont faunas now known from the Devonian in the southern Great Slave Lake region of the southern Northwest Territories (Norris and Uyeno, in Day et al., *in press*) indicate that the Keg River and Methy formations are the Spillville equivalents in the southern N.W.T., and that the Pine Point succession correlates with the Pinicon

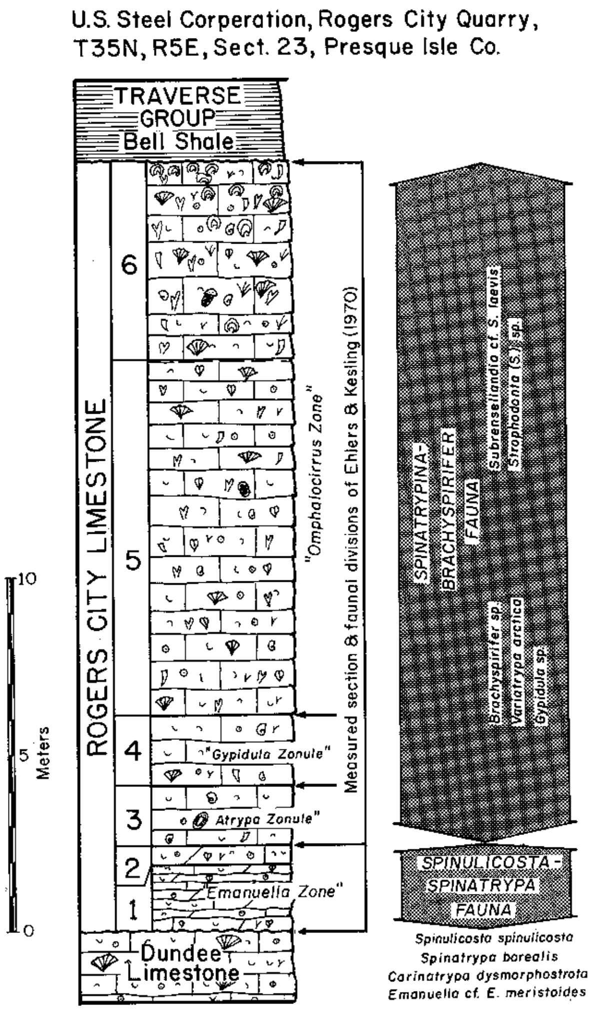


Figure 5. Faunal subdivisions and stratigraphy of the Middle Devonian Rogers City Limestone in its type area near Rogers City Michigan (adapted from the section description of the type section in Ehlers and Kesling, 1970). Correlations of the *Emanuella* and *Omphalocirrus* zones of the Rogers City and the *Spinulicosta-Spinatrypa* and *Spinatrypina-Brachyspirifer*? faunas of the Spillville are shown. Fauna listed for the *Emanuella* and *Omphalocirrus* zones assembled from species listed in various section descriptions in Ehlers and Kesling (1970).

Ridge Formation of Iowa. Correlations and relationships of the Spillville with western Canadian equivalents are outlined in detail by Day et al. (*in press*). Other closely related faunas in central and eastern North America that contain species known from the Spillville fauna include: the Lake Church Formation of Wisconsin (Cleland, 1911; Griesemer, 1965; collections of Koch and Day), the Murray Island Formation of the Hudson Bay Lowlands area of Ontario (Norris, in Sanford and Norris, 1975), and the Stony Hollow Member of the Marcellus Formation in New York (Cooper, 1943; Dutro, 1981; Day and Koch, 1994).

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PTYCTODONTID PLACODERMS? FROM THE UPPER SPRING GROVE MEMBER OF THE PINICON RIDGE FORMATION

William Hickerson
Department of Geology, Augustana College
Rock Island, Illinois

INTRODUCTION

During my undergraduate years at Augustana College I spent many pleasurable days collecting fossils from the Middle Devonian limestones exposed at Milan Stone Quarry (MSQ). A collecting trip to the quarry in the Spring of 1986 yielded a peculiar articulated skeleton, found on the surface of a block that had fallen out of the quarry highwall. At first it was thought to be a primitive fish-like amphibian preserved in a laminated fine-grained sandstone. This lithology is present in Pennsylvanian karst and channel fills within the Devonian carbonates at the quarry. The specimen was sent to Dr. Richard Leary, Illinois State Museum, Springfield, who has done much work on Pennsylvanian faunas and floras from Rock Island County. Dr. Leary sent a photograph of the skeleton to Dr. Hans-Peter Schultze, a Paleozoic fish specialist at the University of Kansas. Dr. Schultze identified the specimen as a partial skeleton of a ptyctodontid fish. Moreover, re-examination of the matrix showed it to be a laminated dolomitic limestone.

A search through other loose blocks at MSQ exhibiting this distinctive lithology, yielded two more complete skeletons in the Spring of 1987. At that time it was noted that the Spring Grove Member of the Pinicon Ridge Formation contained a 2 m sequence of distinctly laminated carbonates. Careful examination of bedding plane exposures of the Spring Grove exposed on the former lower quarry bench revealed another complete skeleton preserved *in-situ*. Excavation of the bench over the next two years produced abundant ptyctodontid material, including complete skeletons, partial skeletons, completely disarticulated skeletons and isolated elements (Hickerson, 1992). Other fauna present in the upper Spring Grove are: medusoid impressions, branching organisms (perhaps a colonial hydroid or sponge), stromatolite mounds, algal mats and subvertical burrows. A poorly preserved arthrodire? cranium was the only fossil recovered from the lower Spring Grove Member. Additionally, ostracodes have been reported (Pearson, 1982) from the Spring Grove Member. at other localities in Eastern Iowa. Ostracodes are abundant in the basal 10 cm of the Davenport Member, directly overlying the upper Spring Grove at MSQ (Figure 1).

STRATIGRAPHY AND LITHOLOGY OF THE SPRING GROVE MEMBER

Thickness of the Pinicon Ridge Formation ranges from 17 to 20 m in the Quad-Cities area (Witzke et al, 1985). Although lacking conodonts or diagnostic mega-fossils, its stratigraphic position suggests an early to middle Givetian age (Witzke et al, 1989). Three members are present, in ascending order: Kenwood, Spring Grove, and Davenport.

At MSQ the Spring Grove Member is approximately 6 m thick. The lower contact with the argillaceous Kenwood Member is sharp, while the upper contact with the Davenport Member varies from distinct to gradational. At a measured section on the west side of MSQ (Fig. 1) the laminated dolomitic limestones of the upper Spring Grove Member are sharply overlain by a massive bedded calcilutite (ostracode pelmicrite) of the basal Davenport Member. However, in other parts of the quarry and elsewhere in the area the laminated dolomitic limestones of the upper Spring Grove Member are overlain by laminated calcilutites of

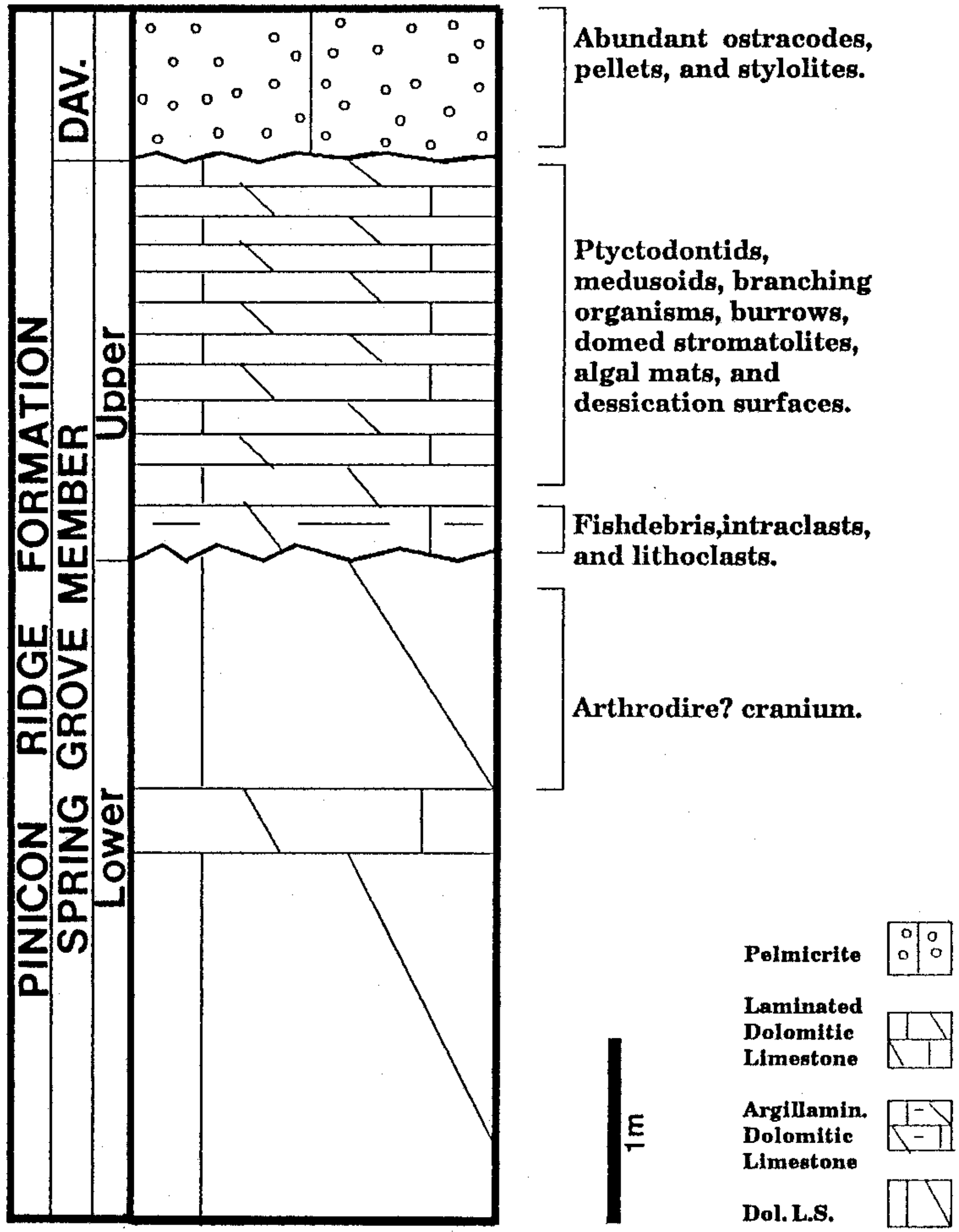


Figure 1. Measured stratigraphic section of the Spring Grove and basal Davenport members of the Pinicon Ridge Formation illustrating the distribution of fossils and lithologic features.

the Davenport Member. At these localities the contact between members can be drawn at the transition point between the rusty-brown colored dolomitic Spring Grove Member and the light gray calcilutites of the basal Davenport Member. Distinguishing characteristics of the Spring Grove Member include: 1) light to dark rusty brown color, 2) high porosities, 3) faint to distinct crenulate laminations, and 4) a distinct petroliferous odor when broken (see Church, 1967; Pearson, 1982; and Sammis, 1978, for detailed petrology).

The Spring Grove Member at MSQ can be divided into upper and lower units, that are lithologically distinct and separated by a prominent unconformity. Occurring directly above the erosional surface is a wavy-bedded, argillaceous, laminated, dolomitic limestone approximately 20 cm in thickness. This bed contains isolated fish elements, intraclasts, and lithoclasts. Charles Collinson (in Edmund and Anderson, 1967) recognized ~1.5 m of Spring Grove Member at MSQ and assigned the dolomitic limestones below the unconformity to the Kenwood Member. Witzke et al. (1985) recognized a thicker Spring Grove Member section (6 m) that included the dolomitic interval below the unconformity.

The lower Spring Grove Member is a massive bedded, highly porous, faintly laminated, mottled dolomitic limestone with numerous crystal vugs (calcite, pyrite, and sphalerite) and is brecciated in places. The upper Spring Grove Member consists of approximately 1.5 m of flaggy weathering, distinctly laminated, dolomitic limestones. The crenulate laminations are organic in nature and range in color from amber to brown. Similar bituminous films have been interpreted as algal mats, indicative of supratidal facies (Friedman, 1969 and Laporte, 1975). A prominent desiccation surface exhibiting large polygonal, calcite filled cracks (~25 cm across) occur in the upper 50 cm of the upper Spring Grove Member at MSQ. During the excavation of the former lower bench at the quarry, many ptyctodontid skeletons and medusoid impressions were collected from directly above and below this desiccation surface. Moreover, two completely articulated ptyctodontid skeletons were collected from within the large shrinkage cracks on the desiccation surface. Laterally, the lithology that produces ptyctodontids is difficult to trace. At MSQ the upper Spring Grove is brecciated or disturbed in places and at nearby Allied Stone Quarry (~2 km North) these beds are lithologically distinct and apparently unfossiliferous. The upper Spring Grove Member at Allied Stone Quarry differs from equivalent beds at MSQ in: 1) being less dolomitic, 2) having nearly horizontal laminations, 3) the occurrence of abundant black carbonaceous partings, and 4) lacking ptyctodontids and associated fauna.

DEPOSITIONAL ENVIRONMENT OF THE UPPER SPRING GROVE MEMBER

Evidence suggests the upper Spring Grove Member was deposited in a supratidal environmental setting. Friedman (1969) lists the characteristics of supratidal facies, these include: 1) the presence of finely laminated dolostones or dolmitic limestones, 2) stromatolitic structures, 3) "birdseye" textures, 4) mudcracks, 5) bituminous material, 6) authigenic feldspar, 7) a dearth of fossils, and 8) an abundance of trace fossils and burrow mottles. All of the above features, with the exceptions of #6 and #8 characterize the Spring Grove Member at MSQ. Trace fossils are present, but are not common. Conversely, Witzke et al. (1989) interpret the Spring Grove as being deposited in a subtidal setting, characterized by restricted circulation. The laminated nature of the deposit in their model is due to density stratification.

The following lithologic features indicative of deposition in a shallow, hypersaline, quiet water environment are present within the upper Spring Grove at MSQ: 1) the stratigraphic sequence is entirely composed of laminated dolomitic limestone, 2) desiccation surfaces are common in the upper 1 m, 3) bituminous partings (algal mats) are common, 4) domed stromatolites have been noted, 5) micro-breccias are seen in thin section, 6) gypsum lithoclasts are present, and 7) macrofossils are rare.

The Spring Grove fauna is interpreted as having lived in this shallow, hypersaline environment. The high degree of articulation displayed by the ptyctodontid skeletons and preservation of delicate medusoids and branching organisms indicates that little, if any hydrodynamic transport occurred. The fish and medusoids swam among the algal mats, domed stromatolites and sessile branching organisms, perhaps feeding on ostracodes. A comparable depositional environment is suggested by Briggs and Clarkson (1983) for the Lower Carboniferous Granton Shrimp Bed in Scotland. The Granton fauna includes shrimp, fish, worm-like organisms, a branching organism (hydroid?), and the conodont animal preserved in a laminated dolomitic limestone. Other lithologic similarities between the "shrimp-bed" and the upper Spring Grove Member are: alternating laminae of calcareous mud and dark brown or black carbonaceous material, desiccation cracks, micro-breccias, convolution of laminae, and stromatolitic structures. The Granton fauna is interpreted as being preserved among intertidal algal mats that were at times exposed to the air and subjected to drying and cracking.

WHAT ARE PTYCTODONTIDS?

Ptyctodontids are an enigmatic group of small to medium sized (most less than 20 cm) placoderms?, characterized by reduction of cranial and trunk-shield dermal armor. They possess a single pair of distinctive upper and lower tooth plates and exhibit strong sexual dimorphism. This group is particularly well represented in the Devonian deposits of eastern Iowa and northwestern Illinois. Three genera of articulated ptyctodontids are now known from the Spring Grove and Davenport members of the Pinicon Ridge Formation in Rock Island County and the Rapid Member of the Little Cedar Formation at Waterloo, Iowa (Denison, 1985). This is significant because articulated ptyctodontids with preserved post-cranial material are quite rare throughout the rest of the world (3 other genera).

Over the years there have been many hypotheses concerning the relationships of ptyctodontids. They have been related to: 1) chimaeroids (Orvig, 1980), 2) arthrodire placoderms (Westoll, 1962), 3) petalichthyid placoderms (Obruchev, 1967), and 4) acanthothoracid and rhenanid placoderms (Denison, 1975). Miles and Young (1977) concluded that the presence of claspers separates ptyctodontids from all other placoderms. Perhaps Miles and Young (1977, p. 137) best sum up the phylogenic uncertainties of this unique group of fish: "The ptyctodontids are morphologically well known placoderms and we feel that it should be possible now to propose a plausible hypothesis of their relationships. But clearly this is difficult because the group exhibits, for the most part, a mixture of primitive characters and specializations not shared by any other group. A bold new conjecture is required that can be put in testable form".

Ptyctodontids were a highly successful group of fish during the Devonian, inhabiting a variety of environments worldwide. Thus they are poor environmental indicators. Ptyctodontids are known from fluvial-brackish deposits (Old Red Sandstone), open marine limestones (e.g., Cedar Valley Group), offshore shales and siltstones (e.g., Sweetland Creek), and now from the shallow, hypersaline, depositional environment of the Spring Grove Member.

Within the Little Cedar Formation of eastern Iowa and northwestern Illinois, ptyctodontids are present in a wide variety of biofacies (Fig. 2), including: brachiopod/bryozoan argillaceous calcilutites (lower and middle Rapid Member), coral/stromatoporoid biostromes (upper Solon and Rapid members), and encrinal calcarenite (upper Rapid Member). Ptyctodontids also occur in all of the distinct fish associations present in the Pinicon Ridge and Little Cedar formations. They dominate the fish fauna preserved in the Pinicon Ridge Formation (E.-M. Givetian) and are present in large numbers (at least 2 species) and associated with large arthrodires (total length > 2 m) in the basal Solon and Rapid members (L. Givetian). Ptyctodontids are associated with onychodontid crosso-pterygians (*Onychodus* sp.) and dipnoans (*Dipterus*) in the lower middle Rapid and they are present in the diverse upper Rapid Member fish fauna, that also includes large placoderms (2 or 3 genera), onychodontids, with cladodontid ("*Cladodus*") and ctenacanthoid (*Phoebodus*) sharks.

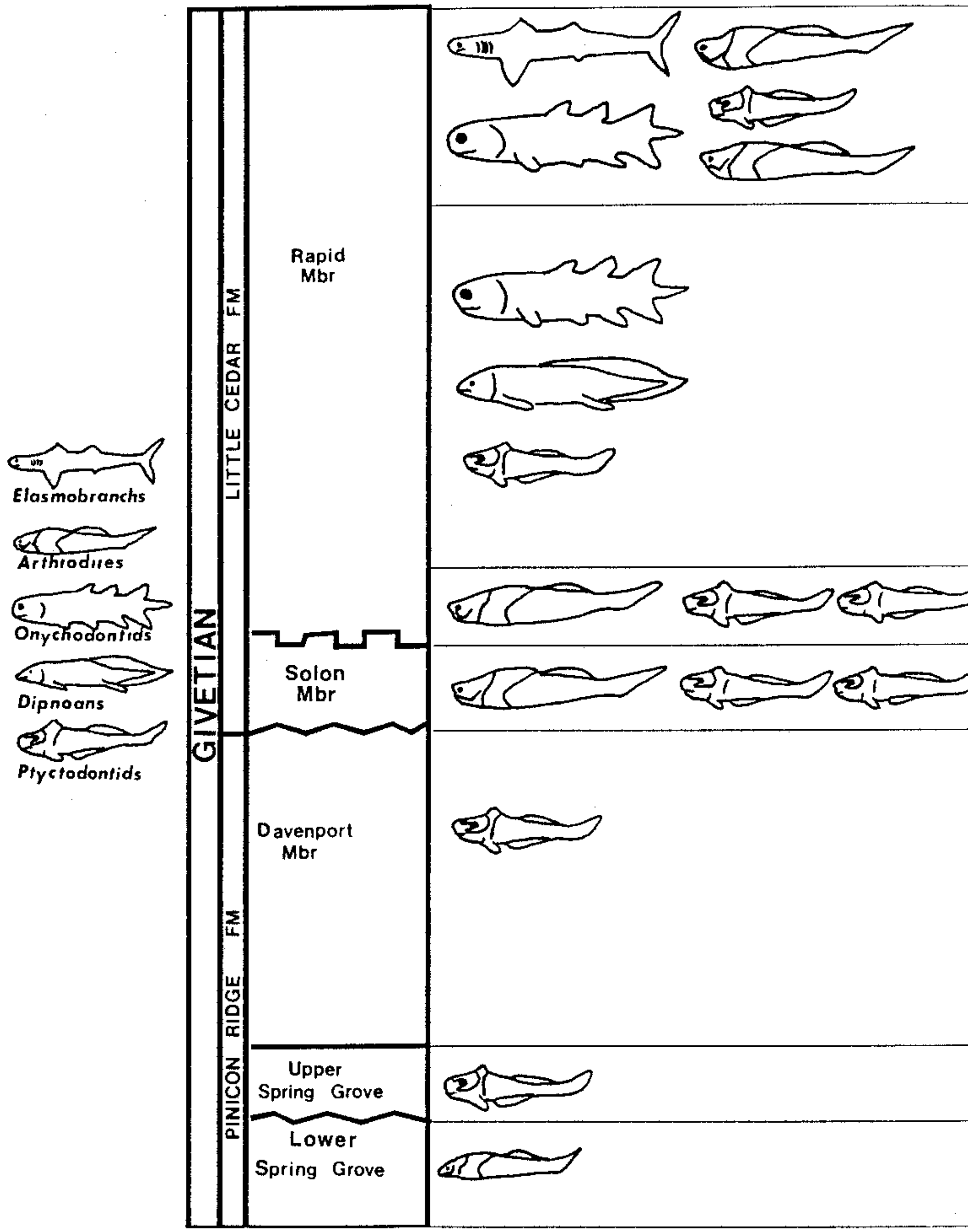


Figure 2. Diagram illustrating the distribution of ptyctodontids and other Middle Devonian fish groups within the Pinicon Ridge and Little Cedar formations of Rock Island County, Illinois.

PTYCTODONTIDS FROM THE UPPER SPRING GROVE MEMBER

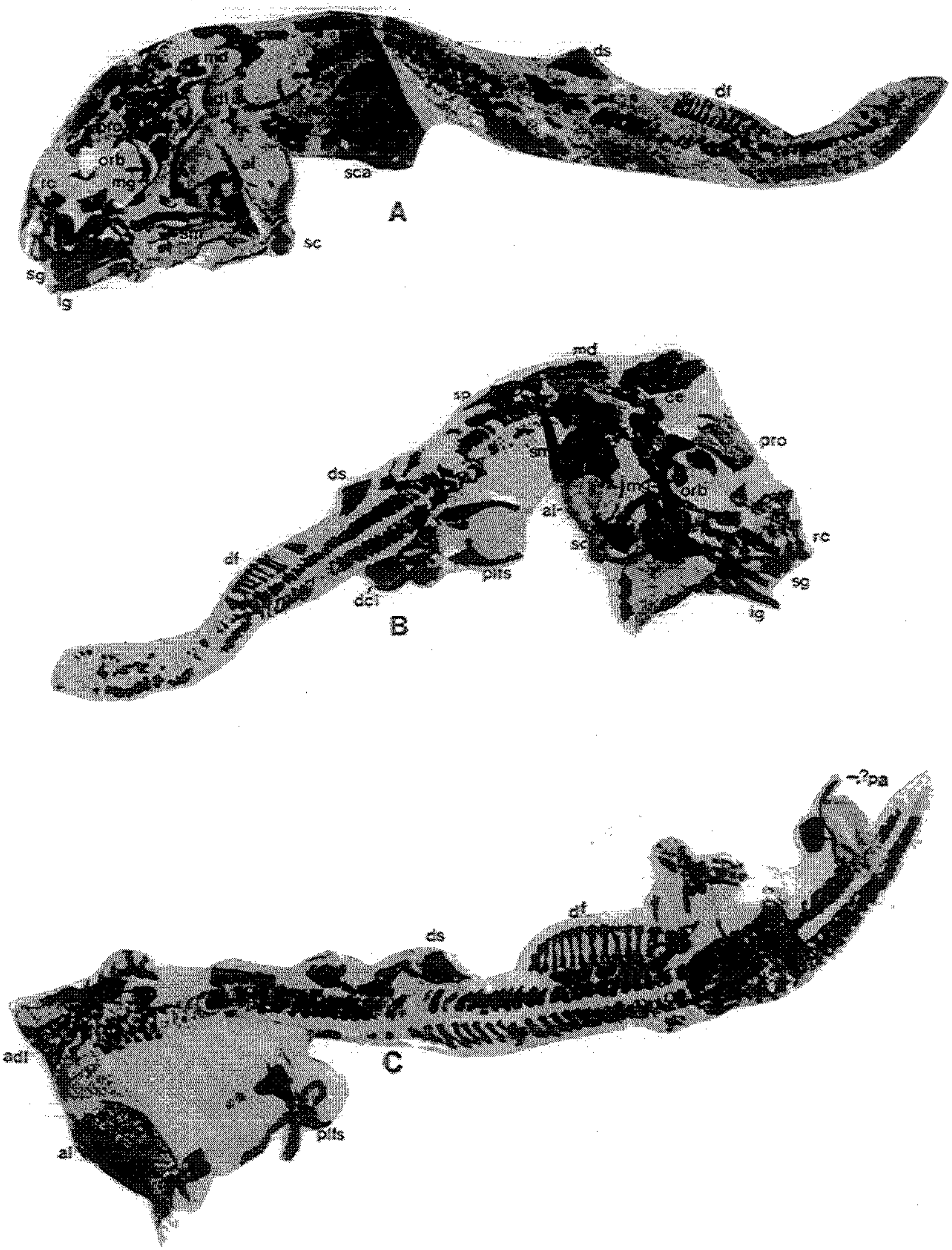
Well preserved ptyctodontids collected from the Spring Grove Member (Fig. 3) may, with further study, contribute to understanding the relationships of this enigmatic group of fish. The specimens are beautifully preserved, similar in quality and detail to fossil fish from the lithographic limestones of Solnhofen, Germany and the marls of the Green River Formation, western United States. The skeletons are compressed laterally, dorsal-ventrally, or ventral-dorsally, somewhat distorting the original shapes of various skeletal elements. They are black in color, being inundated with bitumen. Ptyctodontids (*Rhamphodopsis*) from the Old Red Sandstone of Scotland (Miles, 1967) are similarly inundated.

Nine more or less completely articulated individuals, as well as 30 disarticulated skeletons, and 15 isolated elements were collected at MSQ. Within the suite of disarticulated skeletons the degree of disarticulation ranges from slight to complete. Given the lack of evidence for benthonic scavenging organisms in the Spring Grove Member, it is likely that the disarticulation of most of the skeletons was due to decay of soft tissues holding the skeleton together or "bursting" of gas filled bloated carcasses. It is conceivable that some specimens were ripped apart by an unknown pelagic predator. Given the relative abundance of this small fish (7-10 cm in length) it is probable that the remains of a rare larger predator will eventually turn up in the upper Spring Grove Member. An arthrodire? cranium found in the upper portion of the lower Spring Grove at MSQ indicates larger fish are present.

Other comparable, well preserved, complete or partial ptyctodontid skeletons are known from the Old Red Sandstone (*Rhamphodopsis*, Watson, 1938), the Oberer Plattenkalk (*Ctenurella*, Orvig, 1960), Little Cedar Formation (*Ptyctodopsis*, Denison, 1985) and from the Gogo of Western Australia (*Campbellodus* and *Ctenurella*, Miles and Young, 1977). Additionally, a partial ptyctodontid skeleton that appears to differ from the Spring Grove species was collected from the Davenport Member at Allied Stone Quarry. The Oberer Plattinkalk and Gogo ptyctodontids are Frasnian in age and *Ptyctodopsis* is from the Late Givetian (*subterminus* Fauna, Klapper in Denison, 1985). The exact age of *Rhamphodopsis* is unknown, but it is from the Middle Devonian, thus the Spring Grove specimens (Early Givetian) may represent the earliest articulated ptyctodontids known.

The Spring Grove specimens differ from *Rhamphodopsis*, *Ptyctodopsis*, and *Campbellodus* in lacking a median dorsal spine and strong spinels at the base of the dermal shoulder girdle. Unlike *Ctenurella* it appears that the central plates meet in midline at the posterior edge of the cranium, this condition is also present in *Ptyctodopsis*. *Ctenurella* also has a long, slender, "whip-like" tail as opposed to the short heterocercal tail present in the Spring Grove ptyctodontids. The caudal fin structure of the Spring Grove ptyctodontids is significant because all ptyctodontids have been traditionally reconstructed with chimaeroid (Rat fish) "whip-like" tails. Specimens of *Ctenurella* from Germany (Orvig, 1960) display a long, tapering tail and these specimens have been used as a model for post-cranial reconstructions of less complete ptyctodontids found elsewhere. For example, the specimens of *Rhamphodopsis* illustrated by Miles (1967) show articulated cranial and thoracic shields with incomplete post-cranial material and no speci-

Figure 3. *(Right)* Ptyctodontid skeletons from the upper Spring Grove Member of the Pinicon Ridge Formation. A. Laterally compressed female ptyctodontid of the gracile type. B. Laterally compressed male ptyctodontid of the gracile type. C. Laterally compressed male? ptyctodontid of the robust type. Note the larger dorsal fin and the unidentified paired appendage (?pa) near the end of the caudal fin. Abbreviations used: sg=supragnathal, ig=inferognathal, mg=marginal, orb=orbit, rc=rostral cartilage, pro=preorbital, sm=submarginal, md=medial dorsal, adl=anterior dorsal lateral, al=anterior lateral, sca=pelvic scales, ds=dorsal spine, df=dorsal fin, dcl=dermal claspers, plfs=pelvic fin support, ?pa=unidentified paired appendage.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men displayed a complete tail. Yet *Rhamphodopsis* is reconstructed (Miles, 1967) with the long, tapering tail of *Ctenurella*. Given the many depositional environments inhabited by ptyctodontids it is likely a variety of tail morphologies (at least two) are present within this group. The short, heterocercal tail of the Spring Grove ptyctodontids indicates it was a more active, stronger swimmer than *Ctenurella*. Inhospitable bottom conditions during Spring Grove deposition supports the hypothesis that these ptyctodontids were active, upper water column swimmers.

Completely articulated male (Fig. 3B) and female (Fig. 3A) specimens were recovered, differentiated by the sexual dimorphism of their pelvic fins. The males possess pelvic and prepelvic "claspers" similar to modern holocephalians, while in females the ventral surface of the pelvic fin is covered by a sheet of thick, overlapping scales. This strong sexual dimorphism is well documented by Miles (1967) and Miles and Young (1977).

It is possible that two species of ptyctodontids are represented in the collection from the Spring Grove at MSQ. Two differently shaped upper tooth plates (supragnathals) have been observed in the collection. Additionally, there are two morphotypes, a more gracile form (Figs.3A and B) and one that is more robust (Fig. 3C) in proportions. The robust form is very similar morphologically to the gracile form, differing in having proportionally larger skeletal elements with some elements being slightly different in shape as well (e.g. pelvic fin supports). The robust form also has a larger, "fancier" dorsal fin supported by three basal plates and an unidentified paired appendage (?pa) near the end of the caudal fin (Fig. 3C). The two gracile forms illustrated (Figs. 3A and B) apparently lack basal plates below the dorsal fin. It is possible that basals were present originally in these specimens, though it is difficult to explain, given the high degree of articulation, why they are not present.

CONCLUSION

Ptyctodontid skeletons collected from the upper Spring Grove Member of the Pinicon Ridge Formation at Milan Stone Quarry represent a new genus. They are similar in morphology to other complete ptyctodontids known from the Devonian of the United States, Scotland, Germany, and Australia. However, they differ considerably from all other known ptyctodontids in possessing a short, broad, heterocercal tail rather than the long, tapering, "whip-like" tail that appears in most reconstructions.

Male and female fish can be differentiated by their distinctive pelvic fin structure. Additionally, robust and gracile forms are present, with the robust forms differing only in some minor morphological characters. The presence of an unidentified paired appendage preserved on the caudal fin of one robust specimen indicates two closely related species may be present.

The environment of deposition for the upper Spring Grove Member is interpreted as being supratidal. Ptyctodontids, medusoids, ostracodes, and an unidentified branching organism lived amongst the algal mats and domed stromatolites in a shallow, quiet water environment.

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MIOSPORES OF THE OTIS AND PINICON RIDGE FORMATIONS (MIDDLE DEVONIAN) OF IOWA.

Curtis R. Klug
Department of Geology
The University of Iowa
Iowa City, Iowa 52242

INTRODUCTION AND PREVIOUS WORK

The intent of this paper is to discuss some of the miospore taxa and their biostratigraphic utility for that part of the Wapsipinicon Group exposed in the Quad Cities area. As the information presented in this paper is the result of an ongoing study of the miospores of the Wapsipinicon Group of Iowa, all results should be considered as preliminary.

Miospores are defined as spores less than 200 mμ in diameter regardless of biological function. All of the miospores thus far recovered from the Wapsipinicon strata of Iowa are characterized by the presence of a trilete mark, that is, a triradiate aperture through which the spore contents emerge upon germination. The resistant walls of the miospores and the presence of trilete marks are thought to have been developed as adaptive responses to the effects of desiccation in a subaerial environment. Consequently, the possession of these features is generally considered (e.g. Gray and Boucot, 1977) to indicate derivation of the miospores from terrestrial plants.

Miospores have considerable potential as biostratigraphic tools, particularly for strata of the Devonian Period, for several reasons. First of all, miospore walls are composed of a material called sporopollenin which, with the exception of strong oxidants, is highly resistant to chemical deterioration. This not only promotes preservation of the miospores, but also allows the ready recovery of these fossils from acid insoluble residues. Secondly, the small size (silt to fine sand size) of the miospores protects them from many of the physical processes that prove destructive to larger fossils. The small size and typically high abundance further make these fossils particularly useful where only small samples (as from cores) are available. The small size also promotes distribution of the miospores via wind and water from their terrestrial sources into a variety of depositional environments. Although the presence or absence of miospores in a particular deposit depends upon various physical and chemical aspects of the depositional environment, these aspects are typically independent of the environmental factors required by the parent plants. Consequently, miospores from a single taxon may be recovered, for example, from terrestrial deposits, marine strata bearing biostratigraphically important faunas, or strata deposited in environments devoid of any other fossil forms. Finally, miospores of the Devonian Period should be particularly suited to biostratigraphic application, as this period was a time of rapid expansion of miospore-producing plants into the terrestrial environments. This rapid expansion was apparently accompanied by rapid evolutionary diversification of the Devonian plant life resulting in the introduction of many different taxa across large geographic areas.

LITHOSTRATIGRAPHY AND DEPOSITIONAL ENVIRONMENTS

Norton (1895) first used the name Wapsipinicon in a stratigraphic sense as a "stage" name for "various lower beds of the Devonian series in Iowa". The strata on which Norton based the Wapsipinicon stage typically outcrop along the Wapsipinicon River in Linn County, Iowa. Usage of the name has varied considerably since its original proposal, most significantly by the exclusion of the Independence Shale and "Upper Davenport or

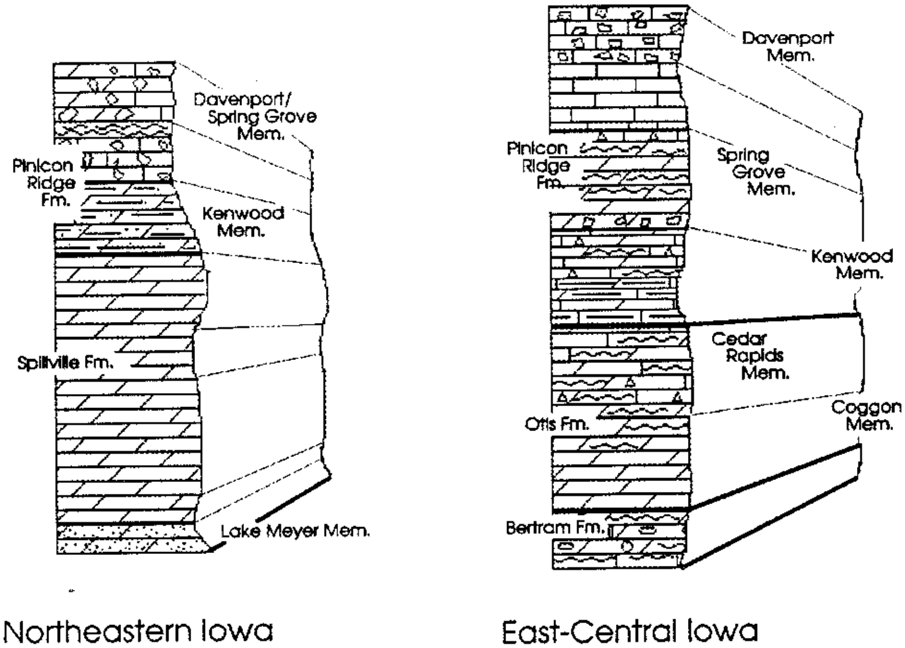

Figure 1. Stratigraphic nomenclature for the Wapsipinicon Group of Iowa.

Gyroceras beds" and the inclusion of the Bertram and Spillville formations and the Coggon Member of the Otis Formation. In the present paper, the Wapsipinicon is treated as a group name following the usage of Witzke, Bunker, and Rogers (1988). Despite the fact that the strata of the Wapsipinicon Group have been reasonably well studied, investigations of the miospore floras from these beds are nearly nonexistent. Only a single species from a single formation in the Wapsipinicon has been previously published (Urban, 1968). To the author's knowledge, the only other paper on miospores of the Wapsipinicon is that of Peppers and Damberger (1969). This paper was based on a miospore-bearing coal from the Wapsipinicon strata of central Illinois.

Strata of the Wapsipinicon Group unconformably overly beds of Ordovician or Silurian age and underly the Middle Devonian beds of the Cedar Valley Group. The Wapsipinicon Group is divided into four formations: the Bertram, Spillville, Otis, and Pinicon Ridge. These formations are further subdivided into a series of members as shown in Figure 1. The strata of the Wapsipinicon occur throughout eastern Iowa (Fig. 2), and extend into adjacent Illinois and Minnesota as well. For the most part, the boundaries of each successively younger unit oversteps those of the underlying unit. Consequently, the Bertram Formation, which is the oldest formation in the group, occupies the smallest geographic area, restricted essentially to Linn and Benton counties, Iowa. The Spillville and Otis formations are presently disjunct but correlative units occurring in northeastern and east-central Iowa, respectively. The youngest formation, the Pinicon Ridge, has the greatest areal extent, occurring across the eastern half of the state. Only the strata of the Otis and Pinicon Ridge Formations are exposed in the Quad Cities area, and the emphasis of this paper will be placed on the miospores of these strata.

The strata of the Wapsipinicon are dominated

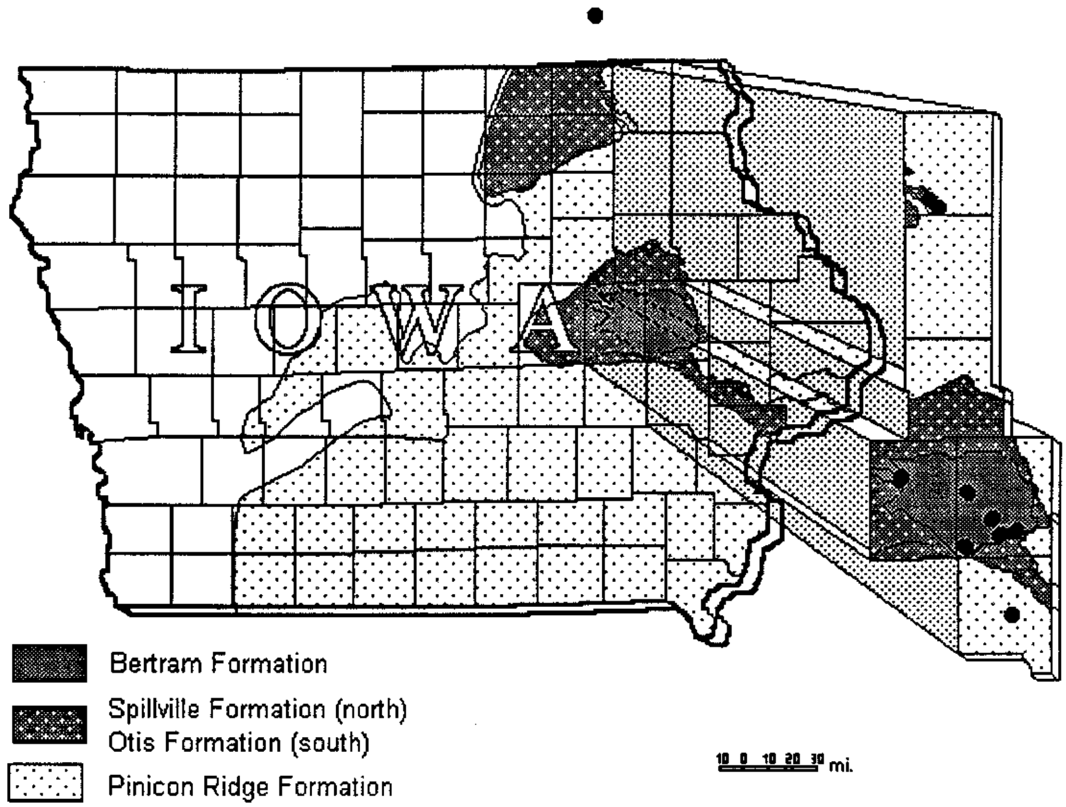

Figure 2. Distribution map of strata of the Wapsipinicon Group in Iowa.

by dolostones and limestones, but shales sands and cherts can also be important components. These strata tend to be nonfossiliferous, although low diversity faunas may occur locally, and parts of the Spillville Formation, in northeastern Iowa, are quite fossiliferous.

The Bertram Formation, stratigraphically the lowest unit in the Wapsipinicon Group, is dominated by vuggy dolostone, but includes some limestone beds and sandy shales, the latter especially at the base. With the possible exception of some very small brachiopods (Norton, 1895) and ostracodes (Church, 1967), no fossils have been reported from the Bertram Formation. The Bertram has been interpreted by Witzke, Bunker, and Rogers (1988) to have been deposited in restricted aquatic to terrestrial environments.

In the type area in Linn County, the Otis Formation overlies Silurian strata or the Bertram Formation. The Otis is subdivided into the Coggon and the overlying Cedar Rapids members. The Coggon Member tends to be a medium to thick bedded dolostone whereas the Cedar Rapids Member is thin to medium bedded limestone and dolostone. This upper member also contains chert nodules and bedded cherts in places. In the Davenport area, however, the Otis consists entirely of limestone, and is not differentiated into members. The Otis Formation is one of the most fossiliferous units of the Wapsipinicon Group, particularly in its lower part. Fossils include brachiopods, gastropods, echinoderms, trilobites, rostroconchs, and conodonts. Although these beds tend to be fossiliferous, faunal diversity tends to be relatively low. Interpreted depositional environments (Witzke, Bunker, and Rogers, 1988) range from rather restricted marine at the base to probable mudflat deposits in the upper part.

In the northeastern part of Iowa, the Spillville is the lowest formation in the Wapsipinicon Group. This is the most fossiliferous unit of the group and is interpreted to represent deposition under the most open marine conditions that existed in Iowa during the deposition of the Wapsipinicon strata. Both the miospores and other fossils recovered from these beds suggest the correlation of the Spillville with part or all of the Otis Formation. As the Spillville Formation does not occur in southern Iowa, a detailed discussion of miospore content and stratigraphy will not be dealt with herein.

The Pinicon Ridge Formation overlies both the Otis and Spillville formations and is divided, in ascending order, into the Kenwood, Spring Grove, and Davenport members. The Kenwood Member tends to be a moderately to strongly argillaceous dolostone or dolomitic limestone, but can include considerable amounts of quartz sand as well. In some parts of the unit, large chert nodules or clasts are also a prominient component. Particularly in southern Iowa, the Kenwood is characterized by the presence of bedded gypsum/anhydrite. Strata of the Kenwood Member have not yet yielded any macrofossils.

The Spring Grove Member of the Pinicon Ridge Formation is dominated by laminated, rather coarsely crystalline dolostones that have a petroliferous odor when freshly broken. Evaporite minerals or pseudomorphs after evaporites are also commonly encountered in this unit. The Spring Grove is generally nonfossiliferous, although stromatolites, ostracodes, and fish (see Hickerson, *this guidebook*) may be found locally.

The Davenport Member is the uppermost unit of both the Pinicon Ridge Formation and the Wapsipinicon Group. This member tends to be composed of very fine-grained, sublithographic limestones and dolostones that are often highly brecciated. In southern Iowa, evaporites (gypsum and anhydrite) are also prominent components. The Davenport Member is generally nonfossiliferous, although stromatolites and ostracodes have been reported.

The abundance of evaporite deposits and the absence of fossils, with the exception of forms that were apparently tolerant of hypersaline conditions, suggests that the Pinicon Ridge sediments were deposited under subtidal to supratidal conditions in a restricted seaway.

MIOSPORES

Samples were collected for miospores from all formations and members of the Wapsipinicon Group in Iowa, as well as from a single locality in southern Minnesota. Miospore abundance in the Wapsipinicon tends to be low compared with standard palynological samples, however, the floras that have been recovered are usually well-preserved and moderately diverse. Many of the Wapsipinicon taxa have not been assigned to known species and appear to represent previously undescribed forms.

All units of the Wapsipinicon Group, with the exception of the Bertram Formation, have produced moderately abundant, well-preserved miospore floras. Oddly enough, the Bertram, is interpreted to have been deposited in the most continental setting of any of the Wapsipinicon formations. The reason for the lack of recovery of miospores from the Bertram is not entirely clear. The interpreted depositional environment of this unit suggests that oxidation may have been the factor that destroyed any miospores that were present. However, some of the samples processed from this unit showed no evidence of strong oxidation and otherwise appeared favorable for miospore recovery. The general absence of fossils in the Bertram has prohibited a definite age assignment for this unit. It was originally considered to be part of the Silurian System, but was later allied with the Devonian on the basis of stratigraphic relationships and lithologic characteristics. If this unit is of Silurian rather than Devonian age, the absence of miospores could be the result of deposition of the Bertram prior to the wide-spread inhabitation of the land by vascular plants. Additional samples of the Bertram Formation from the type locality are being processed for miospores with the intent to resolve this problem.

Actually, the presence of miospores in the strata of the Wapsipinicon Group may be more of a surprise than their absence in any part of the group. As noted above, the Wapsipinicon is dominated by dolostones and limestones, the former occasionally being rather coarsely crystalline. Traverse (1988, p. 425) states that "Most limestones contain very few palynomorphs; dolomites are invariably barren, probably because of secondary recrystallization effects". Neither the strata of the Wapsipinicon Group nor the overlying Cedar Valley Group (Klug, 1990, 1992) support the above statement. The presence or absence of miospores in the Devonian of Iowa apparently depends more upon depositional environment than lithologic composition. It was noted by Klug (1990, 1992) that the miospores in the strata of the Cedar Valley Group tended to be most abundant, diverse, and well preserved in sediments interpreted to have been deposited in the more offshore settings. This generally holds true for the deposits of the Wapsipinicon Group as well. Although this appears contradictory to the presumed terrestrial source of the miospores, the observed distributions are interpreted to be result of transport from the terrestrial environments into the depositional basins primarily via surface runoff and offshore currents. The high diversity of these miospore floras is interpreted to be the consequence of the mixing of spores from a number of upland floras. Low abundance, low diversity miospore floras in the peritidal deposits are interpreted to reflect input from local floras only as the more upland spores bypassed these environments and were deposited further basinward.

In contrast with the Bertram, the Coggon Member of the overlying Otis Formation has produced a moderately extensive miospore flora (Pl. 1) dominated by *Geminospora lemurata* and *Perotriletes selectus*. Species of *Grandispora*, *Stenozonotriletes*, *Rhabdosporites*, and *Densosporites* have also been recovered. *Geminospora lemurata* is a species of widespread distribution and recognized biostratigraphic utility. In fact, this is one of the nominal species of the *Geminospora lemurata* - *Cymbosporites magnificus* miospore zone of Richardson and McGregor (1986). This species has generally been considered to make its first appearance at the base of the Givetian Stage (upper Middle Devonian) (see, for example McGregor & Playford, 1992). However, this species has recently been reported from the slightly older strata of the uppermost part of the Eifelian Stage in the type area (Loboziak, Streel, and Weddige, 1991). *Geminospora lemurata* has also been recovered from the base of the Spillville Formation in northeastern Iowa in direct association with a well-preserved conodont fauna that suggests a Late Eifelian age (Klapper & Barrick, 1983) for at least the lower part of the formation. Although not as widely recognized as *G. lemurata*, *Perotriletes selectus* has elsewhere been reported from strata of Late Eifelian to Early Givetian age and, therefore, agrees with the other miospore and conodont dates for the Coggon Member of the Otis Formation. The miospores from the basal Otis and Spillville formations, therefore, suggests assignment to the *lemurata* - *magnificus* Zone of Richardson and McGregor (1986). However, the apparent absence of *Geminospora lemurata* in the Lake Meyer Member of Spillville Formation, the lack of miospores from the Bertram Formation, and the ages based on conodonts from the basal Spillville in southern Minnesota (Klapper and Barrick, 1983) leave open the possibility that the lowest part of the Wapsipinicon Group in Iowa may belong to the *Densosporites devonicus* - *Grandispora naumovae* Zone of Richardson and McGregor (1986) (see Fig. 3).

Samples from the Cedar Rapids Member of the Otis Formation have produced a somewhat lower diversity miospore flora than those of the Coggon Member. Miospores recovered include *Dibrochosporites nodosus*, *Geminospora lemurata*, *Perotriletes* sp., and *Densosporites* sp. (Pl. 1). *Dibrochosporites nodosus* was established as a new genus and species by James Urban (1968) for miospores recovered from strata in northeastern Iowa that he referred to the Cedar Valley Formation. The section from which Urban collected the holotype of *D. nodosus* has subsequently been removed from the Cedar Valley "Formation" and serves as the type locality of the Spillville Formation (Klapper & Barrick, 1983). Urban's paper on

PLATE 1

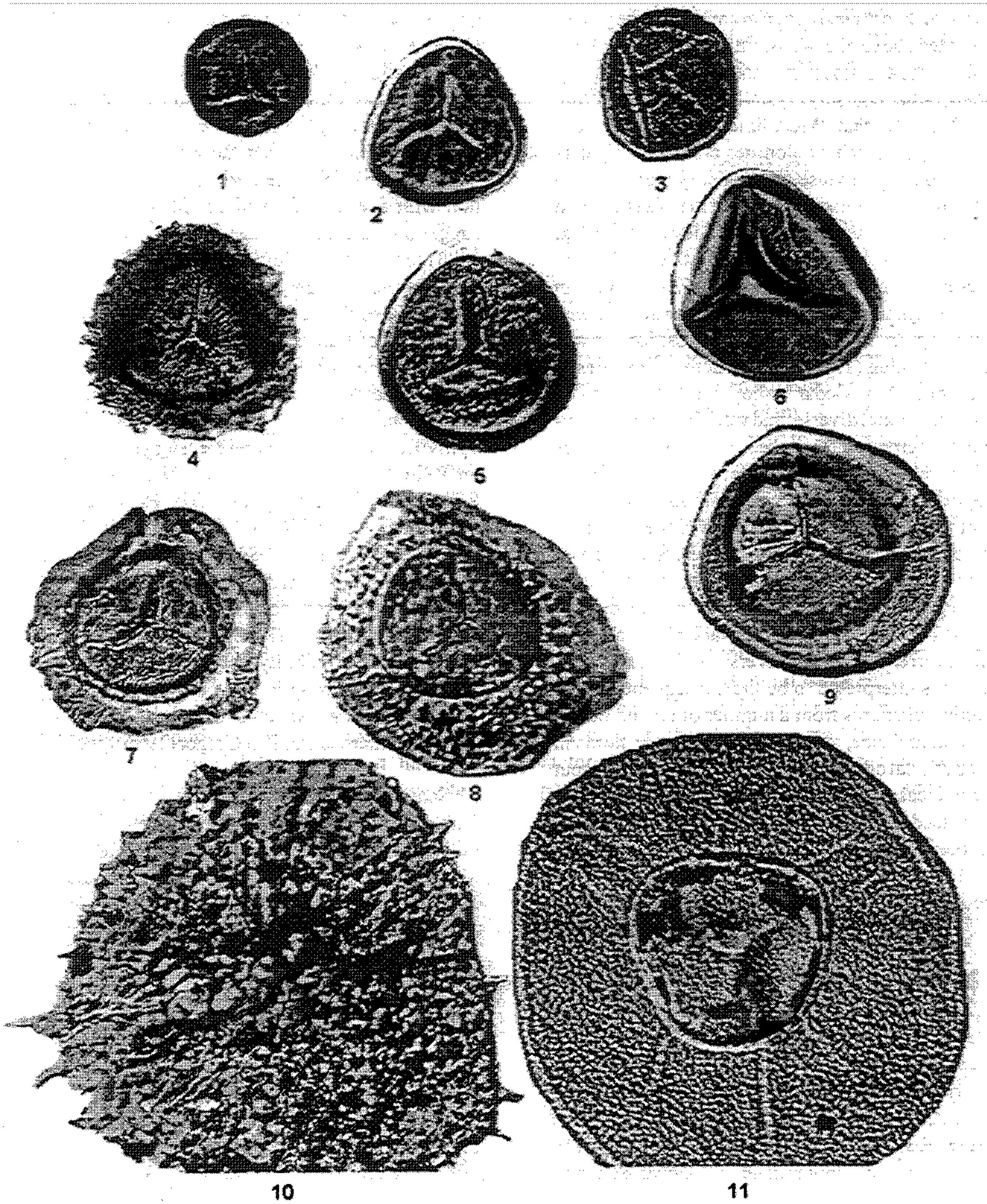

Plate 1. Representative miospores of the Wapsipinicon Group of Iowa. All figures are approximately X700.

Figure 1.	*Punctatisporites*? sp. - Coggon Member, Otis Formation.
Figure 2.	*Stenozonotriletes* sp. - Coggon Member, Otis Formation.
Figure 3.	*Apiculiretusispora plicata* (Allen, 1965) Streel, 1967. - Spring Grove Member, Pinicon Ridge Formation.
Figure 4.	*Densoporites* sp. - Cedar Rapids Member, Otis Formation.
Figure 5.	*Punctatisporites* sp. - Coggon, Member, Otis Formation.
Figure 6.	*Stenozonotriletes* sp. - Coggon Member, Otis Formation.
Figure 7.	*Perotriletes selectus* (Arkhangelskaya, 1963) McGregor & Camfield, 1976 - Coggon Member, Otis Formation.
Figure 8.	*Grandispora* sp. - Coggon Member, Otis Formation.
Figure 9.	*Geminospora lemurata* Balme, 1962 - Coggon Member, Otis Formation.
Figure 10.	*Grandispora naumovae* (Kedo) McGregor, 1973 - Davenport Member, Pinicon Ridge Formation.
Figure 11.	*Dibrochosporites nodosus* Urban, 1968 - Spring Grove member, Pinicon Ridge Formation.

D. nodosus is the only published account of the only miospore species from the Wapsipinicon Group of Iowa. Although Peppers and Damberger (1969) did not report *D. nodosus* from the Wapsipinicon of central Illinois, a single specimen of this species was noted in slides of the Illinois material borrowed from R. A. Peppers of the Illinois State Geological Survey. In addition, the writer has also recovered this species from the lower part of the Thiensville Formation of Wisconsin, a probable correlative of part or all of the Wapsipinicon Group. This species has not been recovered from strata of the overlying Cedar Valley Group of Iowa. *Dibrochosporites nodosus* appears to be a form of potential biostratigraphic value, at least in the Midcontinent Region.

Unconformably overlying the Otis Formation, the Kenwood Member of the overlying Pinicon Ridge Formation is dominated by argillaceous dolostone to dolomitic limestone. Despite the relatively high terrigenous detrital content of the Kenwood Member only a very few miospores have been recovered. None of the forms typical of the underlying and overlying units were recovered from the Kenwood samples. Furthermore, the miospores recovered to date from this unit include no forms of recognized biostratigraphic significance.

Overlying the Kenwood is the Spring Grove Member. As noted above, the Spring Grove consists of laminated, nonfossiliferous, petroliferous, sucrosic dolostone. Evaporite minerals or quartz pseudomorphs after evaporites are common in these beds. Despite the rather foreboding lithology, the Spring Grove produced a moderately diverse assemblage of well-preserved miospores. Miospores occurring in this unit include *Dibrochosporites nodosus, Densosporites devonicus, Rhabdosporites parvulus,* and *Apiculiretusispora plicata* (Pl. 1). This suite of spores suggests a possible age range of Eifelian to Givetian but does not provide any tighter constraints.

The uppermost member of the Wapsipinicon Group is the Davenport Member. The Davenport is commonly brecciated, apparently due to collapse following dissolution of underlying evaporite beds. Unbrecciated strata, however, are frequntly encountered, particularly in the lower parts of the member. A very low diversity miospore flora,

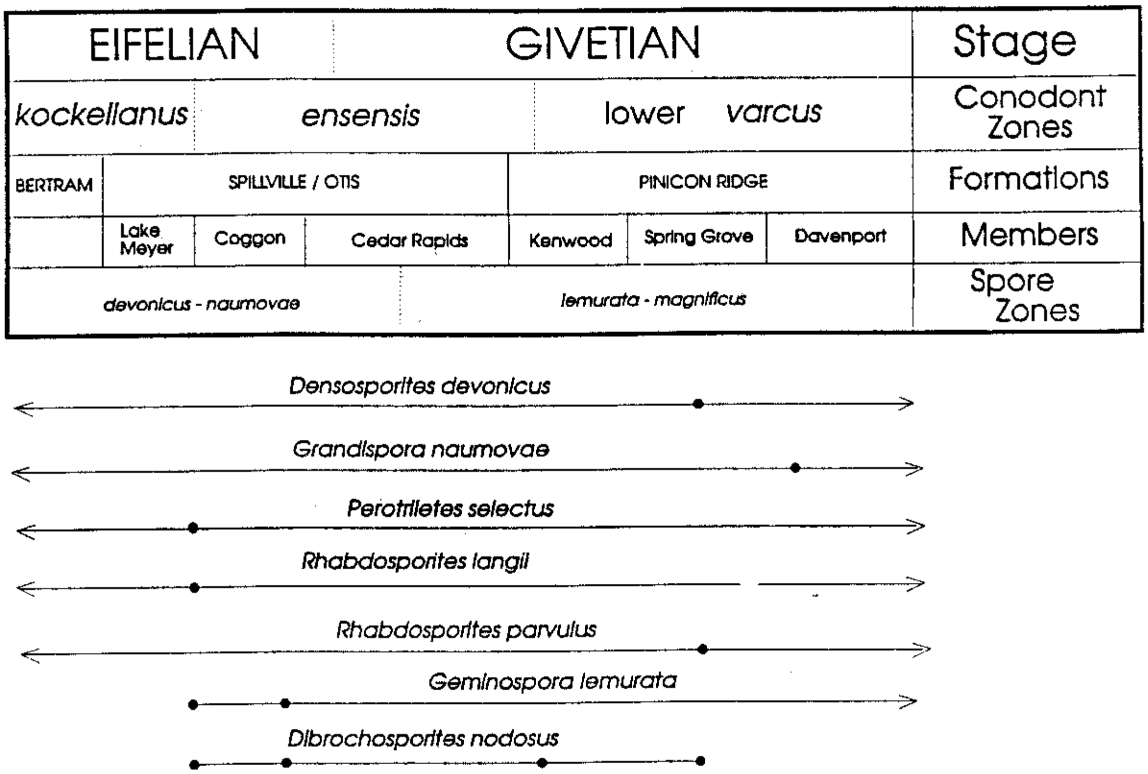

Figure 3. Stratigraphic ranges of select miospores and their biostratigraphic implications for the Wapsipinicon Group of Iowa.

consisting almost exclusively of *Grandispora naumovae* was recovered from the unbrecciated portions of this unit. The spores recovered from this member, however, were well-preserved. Although *Grandispora naumovae* (Pl. 1) is one of the species on which the *devonicus - naumovae* miospore zone of early Eifelian to early Givetian age was based, the range of this species is from Eifelian through the Givetian and probably into the early Frasnian. Consequently, by itself, this species is of limited value in refining the age of the upper part of the Wapsipinicon Group.

CONCLUSIONS

The miospores that have been recovered to date from the Wapsipinicon Group suggest assignment to the *Geminospora lemurata - Cymbosporites magnificus* Zone and possibly the upper part of the *Densosporites devonicus - Grandispora naumovae* miospore zones of Richardson & McGregor (1986). The spores therefore agree with the age assignments of Late Eifelian to Early Givetian based on the limited faunas and stratigraphic position. The *lemurata - magnificus* Zone also occurs in the lower part of the overlying Cedar Valley Group. Consequently, in terms of currently established zones, the miospore biostratigraphy of the Wapsipinicon is about as refined as it can get. However, miospore zones are rather coarse compared with those based on other biostratigraphically useful fossils, such as conodonts. Miospore taxa, such as *Dibrochosporites nodosus,* recovered from additional samples from the Wapsipinicon Group may allow further biostratigraphic refinement at least at the local level. As a better understanding of the full ranges of such taxa is established, it is very likely that the miospore floras of the Wapsipinicon Group will contribute to miospore biostratigraphy in general.

ACKNOWLEDGMENTS

I am grateful to Iowa Science Foundation for support of this project through grant No. ISF-93-33. I would also like to express my thanks to the University of Iowa for access to research facilities and to Russ Peppers of the Illinois State Geological Survey for providing me with slides of the miospores from the Wapsipinicon of Illinois.

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LATE MIDDLE AND EARLY UPPER DEVONIAN BRACHIOPOD FAUNAS OF SOUTHEASTERN IOWA AND NORTHWESTERN ILLINOIS

Jed Day
Department of Geography-Geology, Illinois State University
Normal, Illinois, 61790-4400

INTRODUCTION

Fossiliferous late Middle and early Upper Devonian (Givetian and Frasnian) strata in southeastern Iowa and northwestern Illinois are included in the Cedar Valley Group and the Sweetland Creek Shale (Figs. 1 and 2). Cedar Valley Group strata in this region contain one of the most diverse, abundant, and best documented brachiopod faunas of late Givetian-early Frasnian age known from cratonic carbonate platform deposits in North America.

Strata of the Little Cedar, Coralville, and Lithograph City formations make up the Cedar Valley Group succession in southeastern Iowa in Scott and Muscatine counties, and in Rock Island County in northwestern Illinois (Fig. 1). Strata of the Cedar Valley Group in this region have yielded nearly one hundred species of the nearly one hundred and forty known from these units in the Iowa Basin (see older studies by Day, 1989a, 1989b, 1992). The brachiopod sequence is well understood in the Coralville and Lithograph City formations in the Scott County area (Figs. 2-4), and has yet to be studied in detail in the interval of the Little Cedar Formation (see Hickerson, *this guidebook*). The general aspects of the composition and distribution of the brachiopod and conodont faunas in the Little Cedar Formation at the Lafarge Corporation Quarry in Scott County was outlined in discussions by Witzke et al. (1985).

The purpose of this study is to summarize the more significant aspects of the brachiopod faunas of the Cedar Valley Group in southeastern Iowa and northwestern Illinois for geoscientists and students unfamiliar with these strata and their megafaunas (Figs. 1 and 2). Over 135 species of brachiopods are known from late Givetian-early Frasnian age strata of the Little Cedar, Coralville, and Lithograph City formations in the Iowa Basin as listed in Tables 1-3. A formal brachiopod zonation for the Cedar Valley Group has been formulated in recent studies by Day (1989a, 1992, *in press*) and is shown in Figures 2 and 3. Detailed correlations of the Cedar Valley Group based on the knowledge of concurrent ranges of Devonian brachiopods and conodonts are outlined in older studies by Day (1989a, 1992). Conodont correlations are summarized in Witzke et al. (1985, 1989), Bunker and Witzke (1992), Day (1992), Johnson and Klapper (1992).

LITTLE CEDAR FORMATION

In eastern Iowa, the Little Cedar Formation consists of the basal Solon and overlying Rapid members (Fig. 2). The Little Cedar brachiopod fauna is one of the most diverse, abundant, and best illustrated late Givetian brachiopod faunas known from central and eastern North America. At least ninety-one brachiopod species have been described from the Little Cedar strata in Iowa (Day, 1992; Table 1). The Little Cedar brachiopod sequence is divided now into the *Independatrypa independensis* through the *Neatrypa waterlooensis* zones as defined in Day (1992, *in press*).

Occurrences of brachiopods in the Little Cedar in Scott County (Lafarge Corporation Quarry) are discussed by Witzke et al. (1985), and have yet to be documented in detail. The Little Cedar brachiopod fauna occurs in association with conodonts

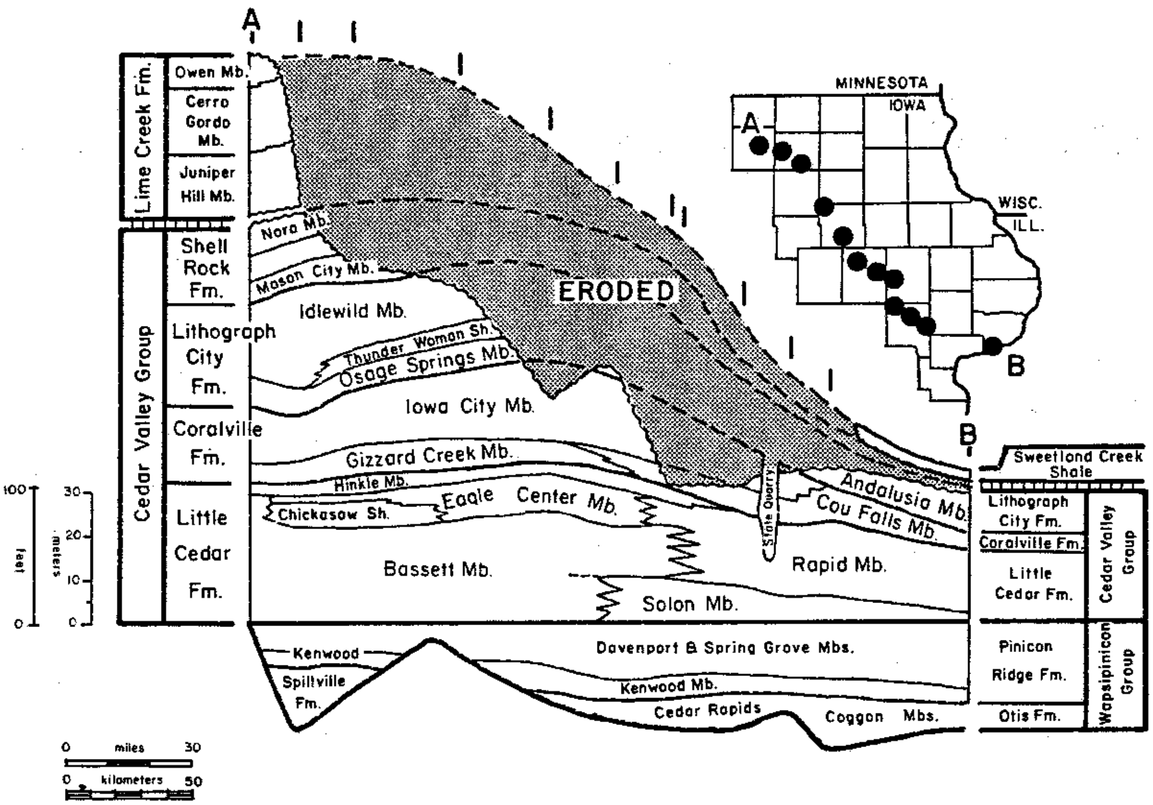

Figure 1. Generalized cross-section of the Middle-Upper Devonian (Eifelian-Frasnian) strata across north-central and eastern Iowa. Modified from fig. 1 of Witzke et al., 1989, after fig. 1 of Day, 1989a; fig. 2 of Day, 1992). Figure 1 of Day and Koch, *this guidebook.*

spanning the interval of the Middle *varcus* Subzone-Lower *subterminus* Fauna (Fig. 3; Witzke et al., 1985, 1989; Bunker and Witzke, 1992; Day, 1992; Johnson and Klapper, 1992).

The brachiopod fauna of the Little Cedar Formation (Table 1, Fig. 3) is characterized by occurrences of species of *Rhyssochonetes, Striatochonetes, Productella, Dichacaenia, Meristella, Echinocoelia, Charionella, Orthospirifer, Tylothyris, Eosyringothyris, Elita, Independatrypa, Neatrypa, Pseudoatrypa, Seratrypa, Spinatrypa (Spinatrypa), Hypothyridina,* and *Atribonium.* Diverse, but largely endemic, species groups of *Strophodonta* (*Strophodonta*), *Pentamerella,* and *Cranaena* also serve to characterize the Little Cedar fauna (Table 1). Seventy-eight brachiopod species are restricted to the Little Cedar Formation, and fourteen (15%) Little Cedar species carryover into younger deposits of the Coralville and Lithograph City formations (Fig. 3; see discussions in Day, 1992).

All but one brachiopod species (a new subspecies of *Tecnocyrtina missouriensis*) known from the Little Cedar and Coralville formations of the Cedar Valley Group (Table 1; Figs. 3) have been described by previous workers. These include: Owen (1852), Hall (1857, 1867), White (1862), Meek and Worthen (1868), Swallow (1860), Hall and Whitfield (1872), Barris (1878), Whitfield (1880), Cleland (1911), Webster (1921), Branson (1923), Fenton and Fenton (1928, 1930, 1935), Cooper and Cloud (1938), Stainbrook (1938a, 1938b, 1940a, 1940b, 1941b, 1942, 1943a, 1943b, 1950), Griesemer (1965), Copper (1973, 1978), Pitrat (1977), Rogers and Pitrat (1987). Some Little Cedar taxa were first described from faunas of units in Missouri (Swallow, 1860; Branson, 1923, 1944; Gregor, 1936; Fraunfelter, 1967, 1974),

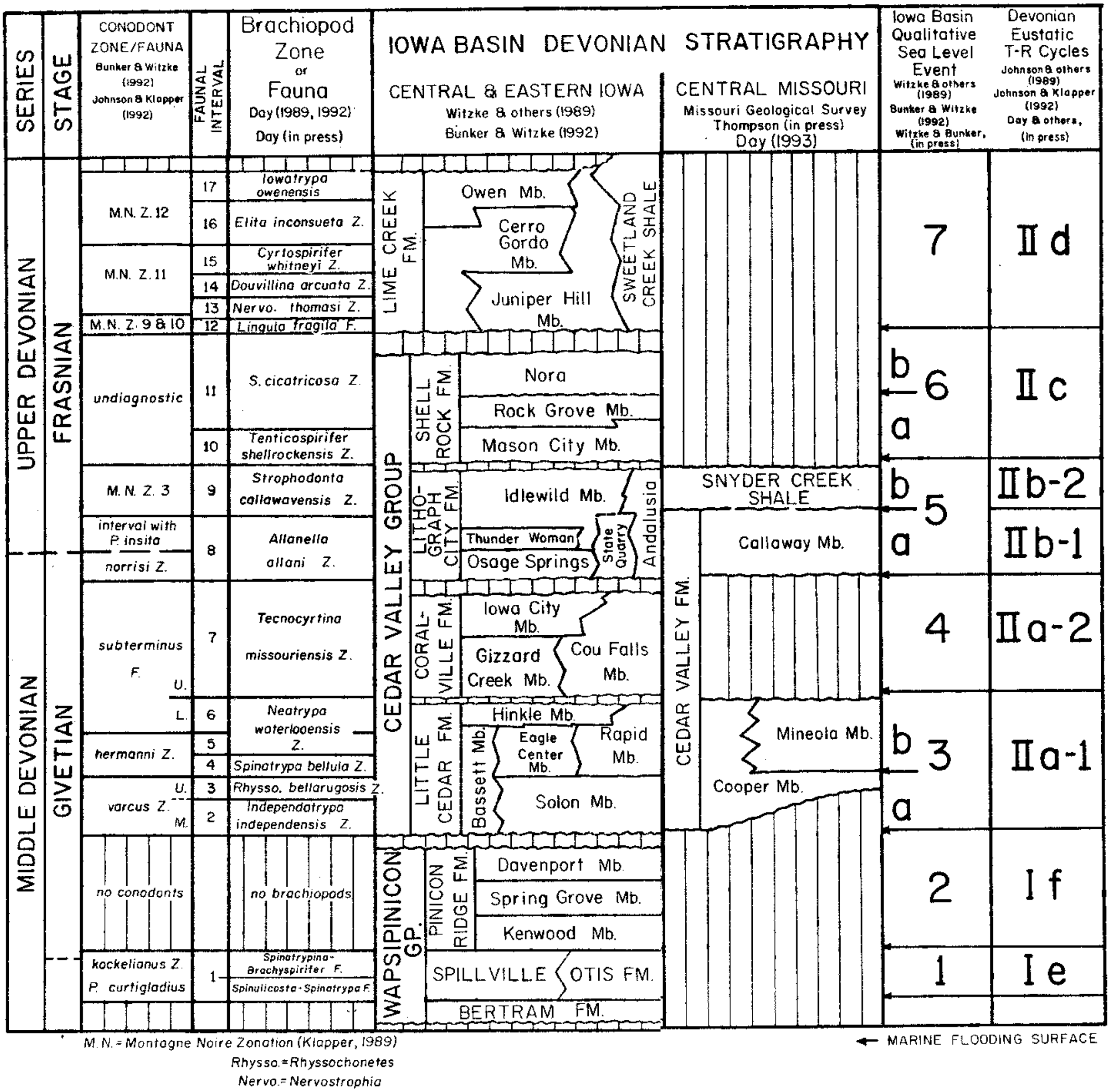

Figure 2. Stratigraphic and biostratigraphic framework for the Middle-early Upper Devonian strata of the Iowa Basin. Also shown are relationships between the Iowa Devonian (Witzke et al., 1989; Bunker and Witzke, 1992; Witzke and Bunker, *in press*), and the Euramerica Devonian sea level curve of Johnson et al. (1985), Johnson and Klapper, 1992, and Day et al. (*in press*). Modified from fig. 3 of Day (1992), with brachiopod biostratigraphy from Day (1989a, 1992, *in press*). Figure 3 of Day and Koch, this guidebook.

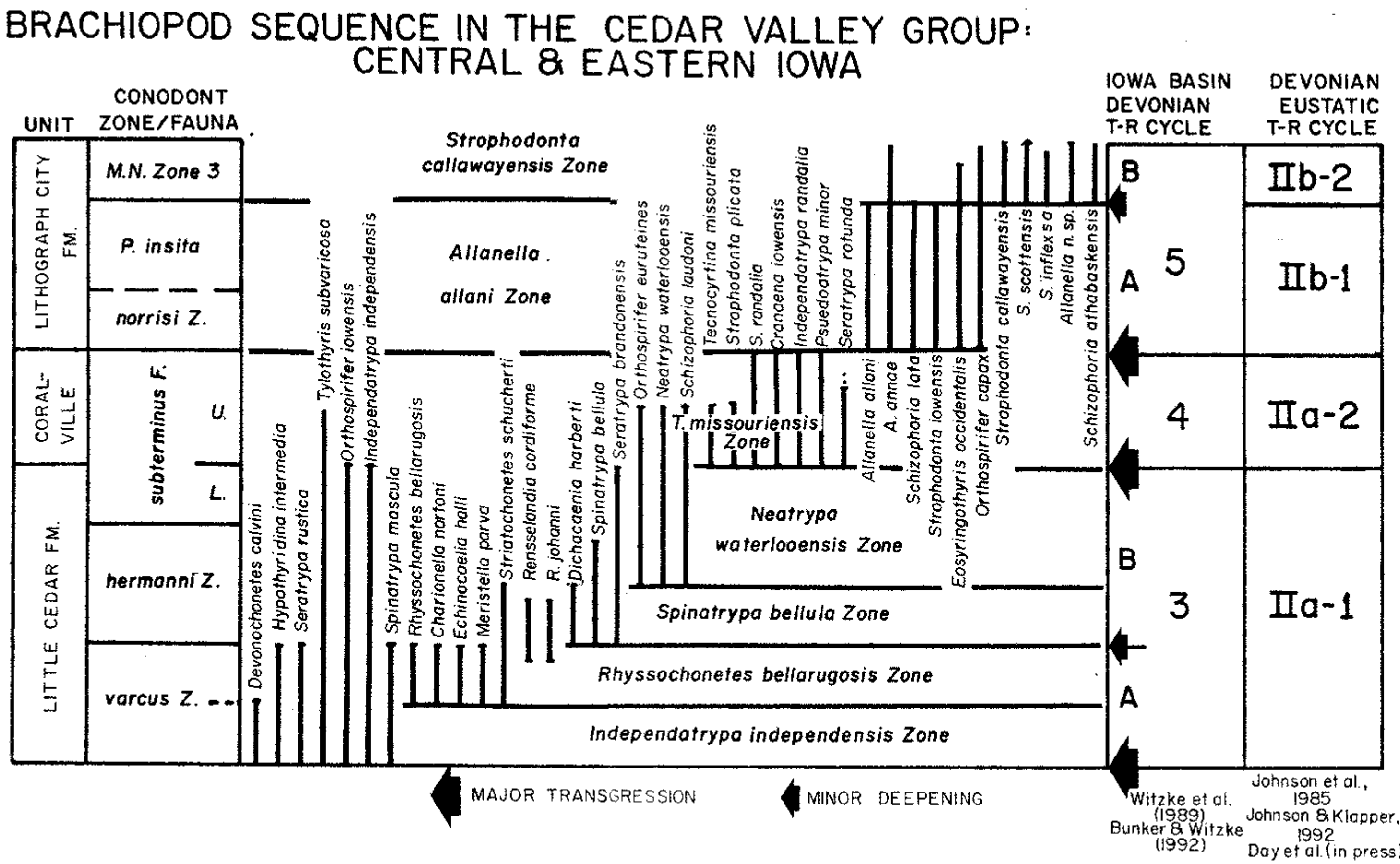

Figure 3. Major features of the late Givetian-early Frasnian brachiopod sequence and zonation of the Cedar Valley Group in central and eastern Iowa. Brachiopod biostratigraphy from Day, 1989a, 1992, *in press.*

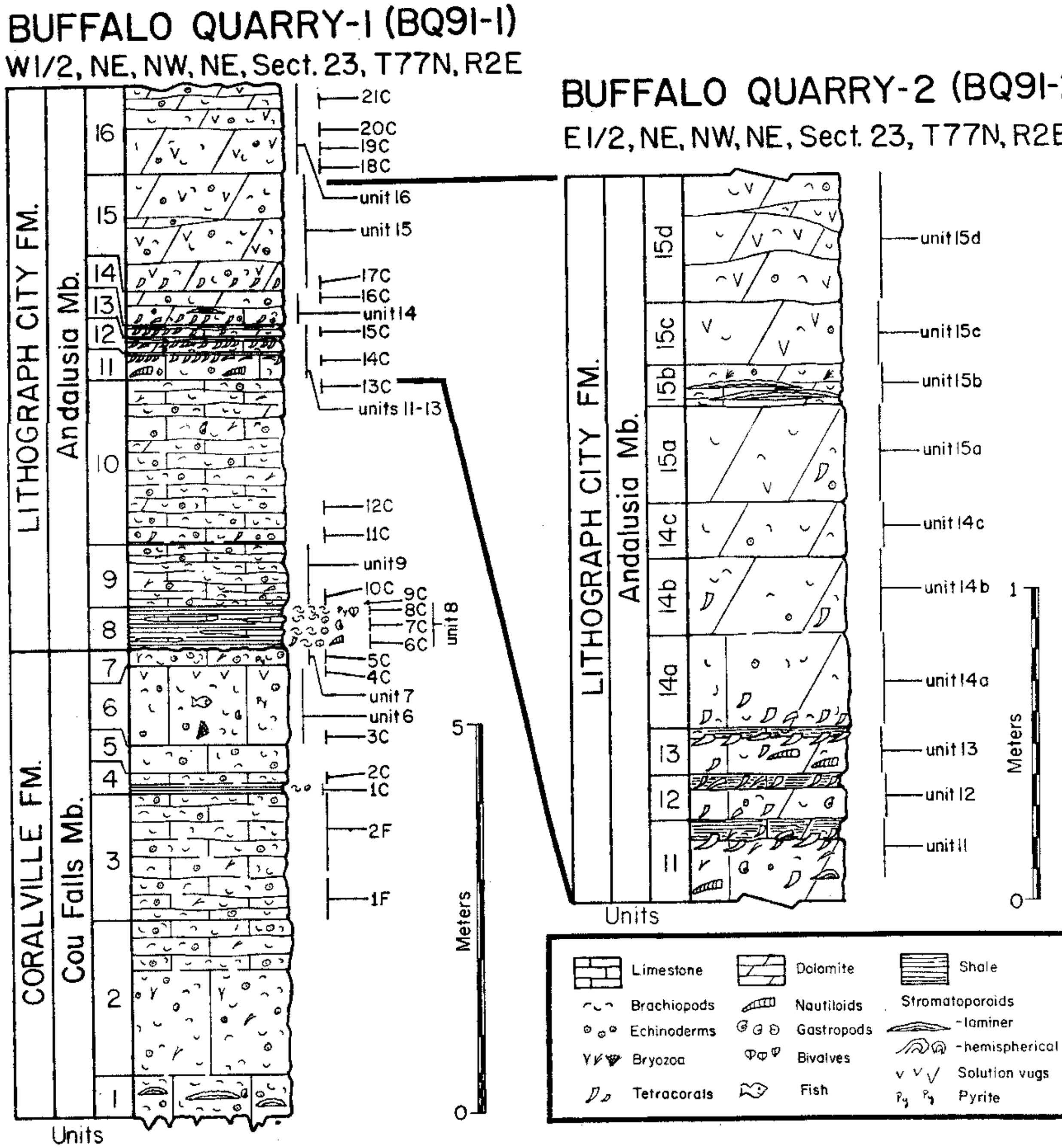

Figure 4. Stratigraphy of the Coralville and Lithograph City formations at the Lafarge Corporation ("Buffalo") Quarry in Scott County, Iowa (=Buffalo Quarry). Detailed section descriptions are featured in the appendix of Day (1992). Modified from fig. 10 of Day (1992).

Table 1. Brachiopod fauna of the Little Cedar Formation of Iowa. Modified from table 1 of Day (1992). Species names preceeded by = are presumed synonyms of preceeding species nomen.

Class-INARTICULATA

Lingula milwaukeensis CLELAND, 1911
Lingulodiscina marginalis (WHITFIELD, 1880)
Orbiculoidea wardi CLELAND, 1911
O. telleri CLELAND, 1911
Petrocrania famelica (HALL & WHITFIELD, 1872)
Philhedra sheldoni (WHITE, 1862)

Class-ARTICULATA

Order-ORTHIDA

Rhipidomella cuneata (OWEN, 1852)
Schizophoria laudoni STAINBROOK, 1940
S. meeki FENTON & FENTON, 1928
S. iowensis HALL, 1858

Order-RHYNCHONELLIDA

Atribonium gregeri (BRANSON, 1923)
A. swallovi (BRANSON, 1923)
Cupularostrum cedarensis (STAINBROOK, 1942)
Hypothyridina intermedia (BARRIS, 1878)
= *H. i. minor* STAINBROOK, 1942

Order-STROPHOMENIDA

Devonochonetes calvini (STAINBROOK, 1943)
Rhyssochonetes bellarugosis (STAINBROOK, 1943)
Striatochonetes buchananensis (STAINBROOK, 1943)
S. schucherti (CLELAND, 1911)
Dichacaenia harberti (STAINBROOK, 1943)
Productella belanskii STAINBROOK, 1943
P. linnensis STAINBROOK, 1943
P. subalata (HALL, 1857)
Eostropholosia littletonensis STAINBROOK, 1943
Protoleptostrophia fragilis (HALL, 1857)
= *Leptostrophia occidentalis* STAINBROOK, 1943
Schuchertella iowensis STAINBROOK, 1943
Floweria? orthoplicata (STAINBROOK, 1943)
Pholidostrophia iowensis (OWEN, 1852)
Strophodonta quadratella STAINBROOK, 1938
S. costata (OWEN, 1852)
= *S. costata independensis* STAINBROOK, 1938
S. dorsata STAINBROOK, 1938
Strophodonta solonensis STAINBROOK, 1938
S. umbonata STAINBROOK, 1938
S. (Strophodonta) cedarensis (STAINBROOK, 1938)
S. (S.) halli (CLELAND, 1911)
S. (S.) linderi (STAINBROOK, 1938)
S. (S.) littletonensis (STAINBROOK, 1938)
S. (S.) parva (OWEN, 1852)
S. (S.) reticulata (STAINBROOK, 1938)
S. (S.) subdemissa (HALL, 1857)

Order-SPIRIFERIDA

Athyris vittata HALL, 1860 (includes varieties *A. v. brandonensis, A. v. randalia* STAINBROOK, 1942
A. zonulata STAINBROOK, 1942
Charionella nortoni STAINBROOK, 1942
Meristella parva COOPER & CLOUD, 1938
Independatrypa independensis (WEBSTER, 1921)
= *Atrypa expansa* WEBSTER, 1921

=*A. independensis janesvillensis* FENTON & FENTON, 1935
Neatrypa brandonensis (STAINBROOK, 1938)
Neatrypa trowbridgei (FENTON & FENTON, 1930)
Neatrypa waterlooensis (WEBSTER, 1921)
=*Atrypa gigantea* WEBSTER, 1921
=*A. waterlooensis websteri* FENTON & FENTON, 1930
=*A. iowensis* FENTON & FENTON, 1935
Neatrypa pronis (FENTON & FENTON, 1935)
=*Atrypa pronis onusta* FENTON & FENTON, 1935
Pseudoatrypa blackhawkensis (STAINBROOK, 1938)
P. bremerensis (STAINBROOK, 1938)
=*Atrypa littletonensis* FENTON & FENTON, 1930
P. bentonensis (STAINBROOK, 1938)
=*Atrypa devoniana tenuicosta* STAINBROOK, 1938
Seratrypa rustica (STAINBROOK, 1938)
Seratrypa brandonensis (STAINBROOK, 1938)
Spinatrypa (Spinatrypa) bellula (STAINBROOK, 1938)
S. (S.) mascula (STAINBROOK, 1938)
S. (S.) occidentalis (HALL, 1858)
Cyrtina triquetra (HALL, 1858)
C. umbonata (HALL, 1858)
Elita subundifera (MEEK & WORTHEN, 1868)
E. minor (STAINBROOK, 1940)
Echinocoelia halli (BRANSON, 1923)
Eosyringothyris aspera (HALL, 1858)
E. thomasi STAINBROOK, 1943
E. triangularis STAINBROOK, 1943
=*E. calvini* STAINBROOK, 1943
Orthospirifer iowensis (OWEN, 1852)
=*O. cedarensis* (OWEN, 1952)
=*O. brandonensis* (STAINBROOK, 1943)
Orthospirifer euruteines (OWEN, 1844)
O. parryanus (HALL, 1858)
Tylothyris bimesialis (HALL, 1858)
T. inultilis (HALL, 1858)
T. megista STAINBROOK, 1943
T. subattenuata (HALL, 1858)
T. subvaricosa (HALL & WHITFIELD, 1872)
=*T. randalia* STAINBROOK, 1943

Order-PENTAMERIDA

Gypidula comis (OWEN, 1852)
G. occidentalis (HALL, 1858)
Pentamerella magna STAINBROOK, 1938
P. rugosa STAINBROOK, 1938
P. subarata STAINBROOK, 1938
P. multicostella CLELAND, 1911
P. laeviuscula (HALL, 1867)
P. obsolescens HALL, 1867

Order-TEREBRATULIDA

Cranaena subglobosa STAINBROOK, 1941
C. inflata STAINBROOK, 1941
C. littletonensis STAINBROOK, 1941
C. romingeri (HALL, 1863)
C. elia (HALL, 1867)
C. jucunda (HALL, 1867)
C. arcuosa STAINBROOK, 1941
C. subcylindrica COOPER & CLOUD, 1938
C. thomasi STAINBROOK, 1941
Rensselandia cordiforme STAINBROOK, 1941
R. johanni HALL, 1867

and Wisconsin (Cleland, 1911; Griesemer, 1965). Stainbrook (ibid.) illustrated and described most of the brachiopod species known from the Little Cedar and Coralville formations (exceptions being Griesemer, 1965; Copper 1973, 1978; Pitrat, 1977; Rogers and Pitrat, 1987).

Solon Member

At least 48 species of brachiopods occur in strata of the Solon Member in eastern Iowa (Day, 1992). Brachiopods are an abundant and conspicuous component of the Solon megafauna in southeastern Iowa and western Illinois, and most assemblages are dominated by atrypids (*Independatrypa, Seratrypa, Pseudoatrypa, Spinatrypa* (*S.*)), strophomenids (*Strophodonta* (*S.*), *Productella*), orthids (*Schizophoria*), and spiriferids (*Orthospirifer, Tylothyris*, or *Eosyringothyris*). The two-fold zonal division of the Solon brachiopod sequence (Figs. 2 and 3) reflects two distinct periods of brachiopod migrations into the Little Cedar seaway of the Iowa Basin. The initial deepening event of Devonian T-R cycle IIa (Iowa Basin Devonian T-R cycle 3A of Fig. 2) that initiated Little Cedar deposition in Iowa and Illinois introduced the elements of the *Independatrypa independensis* Zone, and the latter introduced the distinctive elements of the *Rhyssochonetes bellarugosis* Zone (Day, 1992). Most of these taxa migrated into Iowa from adjacent shelf areas of western and central Canada, the Michigan Basin, and the Appalachian Basin.

Conodont faunas place the base of the Solon (Figs. 2 and 3) in the upper part of the Middle *varcus* Subzone (Klapper and Ziegler, 1967; Bunker and Klapper, 1984; Witzke et al., 1985; Witzke et al., 1989; Bunker and Witzke, 1992; Johnson and Klapper, 1992), and most probably also span the interval of the Upper *varcus* Subzone. The Upper *varcus* Subzone can not be recognized on the basis of the conodont faunas currently known from the upper part of the Solon Member (Witzke et al., 1989; fig. 1, Johnson and Klapper, 1992).

The brachiopod fauna in the lower Solon Member (*independensis* Zone Figs. 2 and 3) consists of 28 species and is characterized by the appearance of *Independatrypa independensis, Hypothyridina intermedia, Schizophoria meeki, Elita minor, Orthospirifer iowensis, Tylothyris inultis, T. subattenuata, T. subvaricosa, Spinatrypa* (*S.*) *mascula, Pseudoatrypa bremerensis*, and *Seratrypa rustica*. At least nine species appear to be restricted to the lower Solon, and include: *Strophodonta* (*S.*) *subdemissa, S. costata, Elita minor, Tylothyris inultis, T. subattenuata, Schizophoria meeki, Floweria*? *orthoplicata, Cranaena thomasi*, and the youngest species of *Devonochonetes* known in midcontinent and western North American faunas (*D. calvini*). Eighteen lower Solon brachiopods range into upper Solon or Rapid strata (Day, 1992, *in press*).

The brachiopod fauna in of the *Rhyssochonetes bellarugosis* Zone of Day (1992) contains as many as 38 species, eighteen of which are carryovers from the lower Solon interval (Figs. 2 and 3). This interval of the Solon Member is characterized by first occurrences of species of *Rhyssochonetes, Striatochonetes, Charionella, Eosyringothyris, Meristella*, and *Echinocoelia* (Fig. 3).

Rapid Member

The brachiopod fauna of the Rapid Member consists of at least 53 species, and the Rapid brachiopod sequence is now divided into a basal *Spinatrypa bellula* and the overlying *Neatrypa waterlooensis* zones (Figs. 2 and 3). The brachiopod fauna in the lower 4.5-5.0 meters of the Rapid Member are now placed in the *Spinatrypa bellula* Zone (Figs. 2 and 3; Day, *in press*), and consists of 30 species (13 of these range up from Solon faunas). Brachiopod assemblages in this part of the Rapid Member occur with conodont faunas of the *hermanni* Zone (Witzke et al., 1989, Bunker and Witzke, 1992; Day, 1992, *in press*; Johnson and Klapper, 1992; Day et al., *in press*). Important elements of the fauna in the lower Rapid include *Dichacaenia harberti, Spinatrypa* (*S.*) *bellula, Rhipidomella cuneata*, and *Seratrypa brandonensis*. Species apparently restricted to the *Spinatrypa bellula* Zone include: *Spinatrypa* (*S.*) *bellula, Rhipidomella cuneata, Strophodonta umbonata, S.* (*S.*) *halli, Elita subundifera,* *Pentamerella subarata, Orbiculoidea telleri,* and *Cranaena inflata* (Day, 1992).

The brachiopod fauna of the middle and upper parts of the Rapid (Figs. 2 and 3) are included in the *Neatrypa waterlooensis* Zone of Day (1992). The brachiopods in the lower part of the *N. waterlooensis* Zone occur with conodont faunas of the *hermanni* Zone. At least 36 species occur in this interval of the Rapid Member, which is characterized by the range inceptions of *N. waterlooensis*, with *Striatochonetes brandonensis, Cyrtina umbonata, Rhipidiorhynchus cedarensis, Orthospirifer euruteines, Strophodonta (S.) parva, Schizophoria laudoni* (see Fig. 3).

Brachiopod assemblages in the upper part of the Rapid Member (Figs. 2 and 3) occur with conodonts of the Lower *subterminus* Fauna (Witzke et al., 1989; Bunker and Witzke, 1992). The upper part of the *Neatrypa waterlooensis* Zone of the Little Cedar Formation yields at least 32 species, with virtually all of these ranging up from older lower and middle Rapid strata (Fig. 3; Day, 1992).

CORALVILLE FORMATION

In Johnson County (Figs. 1 and 2), the Coralville Formation is divided into the Cou Falls and Iowa City members (Witzke et al., 1989; Plocher and Bunker, 1989; Witzke and Bunker, 1992). In Scott County (Fig. 5) Cou Falls Member strata consist entirely of fossiliferous subtidal marine carbonates and minor shales of the Cou Falls Member. The Cou Falls of Scott County is considered to be the offshore equivalents of both the Cou Falls and Iowa City members in the Johnson County area, and the Gizzard Creek and Iowa City members in central and northern Iowa (Figs. 1 and 2).

The Coralville Formation yields brachiopods of the *Tecnocyrtina missouriensis* Zone (Day, 1992) in association with conodonts of the Upper *subterminus* Fauna (Fig. 2; Bunker, 1988; Witzke et al., 1989, Braun et al., 1989; Day et al., 1991; Bunker and Witzke, 1992; Day, 1992). The Upper *subterminus* Fauna is correlated with a position in the upper part of the *disparilis* Zone of the standard Givetian conodont sequence (Johnson et al., 1980, 1985; Witzke et al., 1989; Johnson and Klapper, 1990, 1992; Bunker and Witzke, 1992). The brachiopod fauna of the Coralville Formation consists of least 28 species (Table 2; Figs. 3 and 6). Most Coralville brachiopod taxa are Little Cedar carryovers, or elements of persistent lineages founded by Little Cedar ancestors (including *Athyris, Cranaena, Elita, Independatrypa, Pseudoatrypa, Pentamerella, Seratrypa*). Thus far, specimens of *Tecnocyrtina* have not been recovered from the Cou Falls Member of the Coralville in extreme eastern Iowa or western Illinois, and are restricted to the Gizzard Creek Member in central Iowa.

The bulk of the Coralville fauna is known from the Johnson County area where 20 species occur in skeletal wackestone and muddy coralline-stromatoporoid biostromal packstone facies of the Cou Falls Member. Brachiopods assemblages typically are of lower diversity in Cou Falls strata in the Scott County area as compared to Johnson County to the west. Day (1992) described eight distinctive brachiopod assemblages (designated as "Faunas") from the Gizzard Creek and Cou Falls members of the Coralville Formation in central and eastern Iowa. The ecological distribution of most species of the Coralville brachiopod fauna are shown in Figure 5. The detailed distribution of brachiopod taxa in the Cou Falls Member of the Coralville in Scott County in eastern Iowa is shown in Figure 6. Day (1992) discussed three informal subdivisions (lower, middle, upper) of the Cou Falls Member of the Coralville in Scott County that contain distinctive brachiopod assemblages termed the: *Strophodonta, Athyris-Cyrtina,* and *Pseudoatrypa-Athryis* faunas.

The *Strophodonta* Fauna in the lower Cou Falls Member in Scott County (Fig. 4, units 1 and 2) is characterized by the occurrence of common *Strophodonta (S.) parva, S. (S.) randalia,* with *Cyrtina umbonata, Athyris vitatta, Independatrypa randalia, Pseudoatrypa minor, Tylothyris subvaricosa, Schizophoria laudoni, Atribonium subovata, Cranaena iowensis,* and *C. subovata.* The overlying *Athyris-Cyrtina* Fauna is characterized by the occurrence of abundant *Athyris vitatta* and *Cyrtina umbonata,* with *Strophodonta (S.) randalia, S. (S.) parva, Pseudoatrypa minor,* and

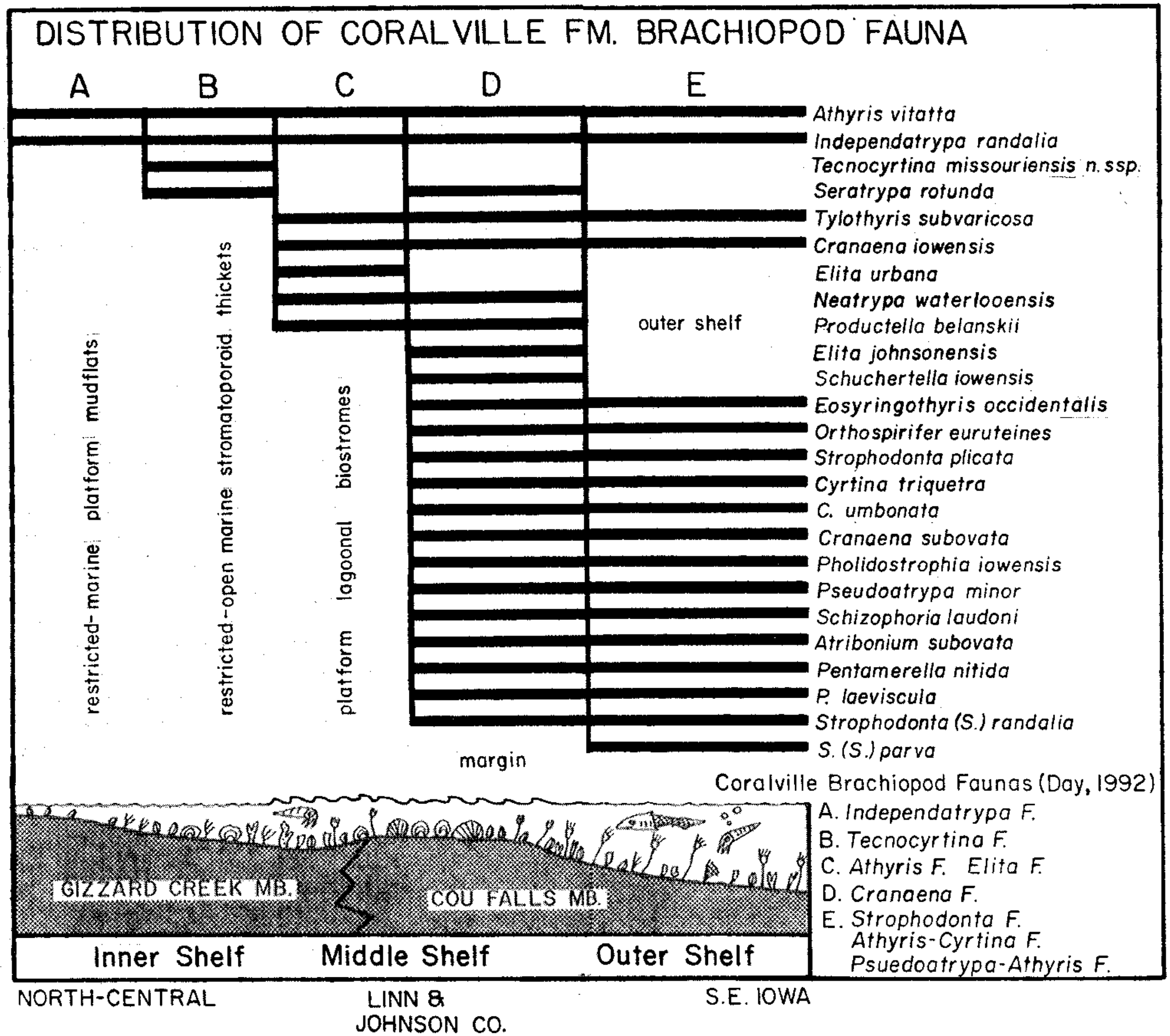

Figure 5. Distribution of important elements of the brachiopod fauna of the Coralville Formation in central and eastern Iowa based on description of Coralville brachiopod "Faunas" in Day (1989a, 1989b, and 1992).

Table 2. Brachiopod fauna of the Coralville Formation. Modified from table 2 of Day (1992).

Class-INARTICULATA

Petrocrania famelica (HALL & WHITFIELD, 1873)

Class-ARTICULATA

Order ORTHIDA

Schizophoria laudoni STAINBROOK, 1940

Order-STROPHOMENIDA

Pholidostrophia iowensis (OWEN, 1852)
Productella? *belanskii* STAINBROOK, 1943
Schuchertella iowensis STAINBROOK, 1943
Strophodonta plicata (HALL)
= *S. occidens* (HALL, 1860)
S. (*S.*) *parva* (OWEN, 1852)
S. (*S.*) *randalia* (STAINBROOK, 1943)

Order-RHYNCHONELLIDA

Atribonium subovata (SAVAGE, 1921)

Order-SPIRIFERIDA

Athyris vitatta HALL, 1860
A. cedarensis STAINBROOK, 1942
Cyrtina triquetra (HALL, 1858)
C. umbonata (HALL, 1858)
Elita johnsonensis (STAINBROOK, 1938)
E. urbana (CALVIN, 1892)
Eosyringothyris aspera (HALL, 1858)
Orthospirifer euruteines (OWEN, 1844)
Tecnocyrtina missouriensis new subspecies
Tylothyris subvaricosa (HALL & Whitfield, 1872)
Independatrypa randalia (STAINBROOK,1938)
Neatrypa waterlooensis (WEBSTER, 1921)
Pseudoatrypa minor (STAINBROOK, 1938)
Seratrypa rotunda (STAINBROOK, 1938)

Order-PENTAMERIDA

Pentamerella dubia HALL
P. laeviscula (HALL, 1867)
P. nitida STAINBROOK, 1938

Order-TEREBRATULIDA

Cranaena iowensis (CALVIN)
Cranaena subovata SAVAGE, 1862

UNIT	CORALVILLE FM. Cou Falls Mb.								LITHOGRAPH CITY FM. Andalusia Mb.																		
ELEVATION	0.00	0.54	2.54	3.17	4.27	4.79	5.62	5.82	6.02	6.58	6.78	7.41	7.81	8.12	9.30	9.50	9.85	10.05	10.20	10.55	10.80	10.98	11.29	11.42	11.62	12.15	13.25
SAMPLE NUMBER	unit 1	unit 2	1F	2F	2C	3C	4C	5C unit 7	unit 8	10C	unit 9	11C	12C	point sample	13C	unit 11	unit 12	unit 13/15C	unit 14a	unit 14b	unit 14c	unit 15a	unit 15b	unit 15c	unit 15d	18C	21C
SAMPLE INTERVAL	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17	18	19	20	21	22	23	24	25	26	27
Athyris vittata	●		●	●			●												●			●	●				
Independatrypa randalia	●					●	●	●																			
Pseudoatrypa minor	●	●	●	●	●	●																					
Schizophoria laudoni	●																										
Orthospirifer euruteines		●	●	●																							
Strophodonta (S.) randalia		●		●		●	●																				
S. (S.) parva		●	●				●	●																			
Cyrtina umbonata		●	●																								
Tylothyris subvaricosa		●					●	●																			
Allanella annae									●		●		●			●			●	●	●	●					
Strophodonta (S.) iowensis									●		●				●												
Eosyringothyris occidentalis									●																		
Floweria n. sp.									●																		
Independatrypa scutiformis									●	●	●	●	●		●							●					
Schizophoria lata									●		●		●														
Orthospirifer capax										●	●			●	●						●						
Tecnocyrtina sp.										●																	
Cyrtina sp. A											●					●	●		●		●						
Strophodonta (S.) callawayensis																●	●	●	●	●	●	●	●	●	●	●	●
Schizophoria athabaskensis																●			●								
Aulopora sp.																●											
Tabulophyllum callawayensis									●							●	●	●	●	●		●					
Elasmonema sp.																	●										
Conocardium sp.																	●										
Cranaena n. sp.																	●		●				●				
Paracyclus rowleyi																				●							
Hadrorhynchia solon																							●				
BRACHIOPOD ZONE	*Tecnocyrtina missouriensis* Zone								*Allanella allani* Zone							*Strophodonta callawayensis* Zone											

Figure 6. Brachiopod sequence developed in the Coralville and Lithograph City formations at the Lafarge Corporation ("Buffalo") Quarry in Scott County, Iowa. Sampled units and intervals shown in Fig. 4 of this report. After fig. 11 of Day (1992).

Orthospirifer euruteines. This fauna occurs in the middle part (Fig. 4, unit 3) of the Cou Falls Member at the Buffalo Quarry. Udden (1899) referred to these strata as the *Athyris vitatta* beds. The *Pseudoatrypa-Athyris* Fauna occurs in shales and argillaceous limestones and dolostones of units 4-7 (Figs. 4 and 6) in the upper Cou Falls Member at the Lafarge Corporation Quarry. This fauna contains abundant *Pseudoatrypa minor, Athyris vittata,* with smaller numbers of *Independatrypa randalia* (Fig. 6). The upper surface of unit 7, at the top of the Coralville Formation (Fig. 4), is a prominent disconformity and sequence boundary.

LITHOGRAPH CITY FORMATION

In eastern Iowa, the Lithograph City Formation is represented by strata placed in the State Quarry Member in Johnson County, and the Andulusia Member in Scott County, Iowa (Figs. 1, 2, and 4). The State Quarry Member in Johnson County consists of a variety of mud- and grain-supported skeletal carbonate lithofacies interpreted as a tidal channel and channel margin mudbank deposits. The Andalusia Member in extreme eastern Iowa (Figs 1, 2 and 4) consists of mud-rich skeletal carbonates, dolomites, and minor shales that accumulated in the distal-deeper parts of the Lithograph City seaway.

The brachiopod fauna of the Lithograph City Formation in Iowa (Figs. 1 and 2) is included in the *Allanella allani* and *Strophodonta callawayensis* zones of Day (1992). Strata of the Lithograph City (defined by Bunker et al., 1986; Witzke et al. 1989) contain a brachiopod fauna of at least 29 species representing 19 genera (Table 3). Most notable of these are distinctive species of *Allanella, Devonoproductus, Eleutherokomma, Eosyringothyris, Hadrorhynchia, Independatrypa, Pseudoatrypa, Spinatrypina, Schizophoria, Strophodonta* (*S.*), and *Cyrtina.* Species of these genera occur in most parts of the Lithograph City Formation in Iowa and its equivalents in Missouri (Fig. 2). The conodont sequence in the Lithograph City spans the interval of the *norrisi* Zone (latest Givetian, see Johnson and Klapper, 1990; Bunker and Witzke, 1992; Day, 1992) through Zone 3 (early Frasnian) of the Frasnian conodont sequence in the Montagne Noire of southwestern France (Klapper, 1989) as recently discussed in Johnson and Klapper (1992) and Day (1992).

The position of the Givetian-Frasnian (Middle-Upper Devonian) stage boundary within the Lithograph City Formation can not be accurately established because conodont faunas in lower part of the Lithograph City Formation do not yield diagnostic species of *Ancyrodella,* and are dominated by *Pandorinellina insita.* This boundary falls at some position in the upper part of the *Allanella allani* Zone of Day (1992), and not at the base of the *Strophodonta* (*S.*) *callawayensis* Zone of the Andalusia Member in extreme eastern Iowa (Figs. 2 and 3) as suggested earlier by Day (1989a, 1992). In central Missouri (Fig. 2), the oldest brachiopod faunas of the *Strophodonta callawayensis* Zone occur in direct association with conodonts of early Frasnian Montagne Noire Zone 3 of Klapper (1989) in the base of the Snyder Creek Shale (Day, 1993).

Twenty-three of the twenty-nine species of brachiopods known from the Lithograph City Formation (Table 3, Figs. 3 and 6) were described by Calvin (1876, 1897), Webster (1921), Branson (1922, 1940), Thomas and Stainbrook (1922), Fenton and Fenton (1924, 1935), Stainbrook and Ladd (1924), Belanski (1928a, 1928b), Stainbrook (1938b, 1943a, 1943b), Warren (1944), and Norris (1983). Day (1986, 1989a, 1989b, 1992) outlined the composition and stratigraphic significance of the Lithograph City brachiopod fauna and outlined detailed correlations with units containing coeval latest Givetian-early Frasnian faunas throughout North America. A variety of distinctive brachiopod assemblages or "Faunas" where described from the Lithograph City Formation of the Iowa Basin in Day (1989a, 1992). Two of these characterize the Andalusia Member in Scott County in southeastern Iowa, and are discussed below.

Andalusia Member

The brachiopod fauna of the Andalusia Member is dominated by species of *Strophodonta* (*S.*), *Schizophoria,* and *Independatrypa* (Day, 1989a).

Table 3. Brachiopod fauna of the Lithograph Formation of north-central and eastern Iowa. Modified from table 3 of Day (1992).

Class-INARTICULATA
Lingula sp. cf *L. milwaukeensis* CLELAND, 1911

Class-ARTICULATA
Order-ORTHIDA
Schizophoria lata STAINBROOK 1940
S. athabaskensis WARREN, 1944

Order-RHYNCHONELLIDA
Hadrorhynchia solon (THOMAS & STAINBROOK, 1921)

Order-STROPHOMENIDA
Devonoproductus reticulocostus NORRIS, 1983
Floweria altirostris (STAINBROOK & LADD, 1922)
F. n. sp. of Day (1989a, 1989b)
Productella sp. cf. *P. fragilis* BELANSKI, 1928
Strophodonta (S.) inflexa (SWALLOW, 1860)
S. (S.) iowensis (STAINBROOK, 1943)
S. (S.) callawayensis (SWALLOW, 1860)
S. (S.) scottensis (BELANSKI, 1928)

Order-SPIRIFERIDA
Allanella allani (WARREN, 1944)
A. annae (SWALLOW, 1860)
A. n. sp. aff. *A. engelmanni* MEEK
Cyrtina sp. A (NORRIS, 1981)
=*Tecnocyrtina* sp. A of NORRIS (in Norris & Uyeno, 1981)
=*Cyrtina triquetra* HALL, in Branson (1922)
Orthospirifer capax (HALL, 1858)
Eleutherokomma n. sp. A.
E. n. sp. B
=*E. jasperensis* of Day (1989a)
Eosyringothyris occidentalis STAINBROOK, 1943
Tecnocyrtina missouriensis curvilineata
Independatrypa scutiformis (STAINBROOK, 1938)
Pseudoatrypa rugatula (STAINBROOK & LADD, 1922)
=*Variatrypa rugatula* of Day (1989a, 1989b)
Pseudoatrypa? *lineata* (WEBSTER, 1921)
=*Atrypa inflata* WEBSTER, 1921
=*Radiatrypa clarkei* of Day (1989a, 1989b)
Spinatrypina (Spinatrypina) n. sp.
=*S.* sp. sf. *S. angusticostata* JOHNSON in Day (1989a, 1989b)
Athyris simplex STAINBROOK & LADD, 1922
A. vittata Hall, 1860
=*A. v. buffaloensis* STAINBROOK, 1942

Order-PENTAMERIDA
Gypidulina n. sp.

Order-TEREBRATULIDA
Cranaena depressa STAINBROOK AND LADD, 1922
C. infrequens BELANSKI, 1928
C. n. sp.

This unit is best exposed at the Lafarge Corporation Quarry near the town of Buffalo (Fig. 4) in Scott County, Iowa. Additional exposures of the Andalusia Member can be seen to the west in stream drainages near the town of Montpelier, and along Pine Creek in Muscatine County, Iowa. Hall (1858) and Stainbrook (1938b, 1940b, 1942, 1943a, 1943b) described most of the fauna known from the Andalusia Member at exposures near Buffalo along the Mississippi River. Stainbrook (1938b, 1943a) described atrypid, strophodontid, and spiriferid (1943b) brachiopods from strata designated as the "*Stropheodonta iowensis* zonule" of the "*waterlooensis* Zone".

Day (1989a, 1992) assigned the brachiopod fauna from the lower part of the Andalusia Member to the lower *Strophodonta* Fauna. At the Lafarge Corporation Quarry in Scott County, the "lower" Andalusia Member (Figs. 4 and 6; units 8-10, samples 9-14) contains a brachiopod fauna consisting of extremely abundant *Strophodonta* (*S.*) *iowensis*, with smaller numbers of *Independatrypa scutiformis*, and *Schizophoria lata*. *Athyris vittata*, *Tecnocyrtina missouriensis*, *Allanella annae*, *Eosyringothyris occidentalis*, and *Floweria* sp. Specimens of the solitary tetracoral *Tabulophyllum callawayense* also occur in shales and argillaceous skeletal packstones of the "lower Andalusia (Fig. 4, units 8-10). Hall (1858) and Stainbrook (1938, 1940a, 1943a) described most of the "lower" Andalusia species from the basal shale (unit 8 of Fig. 4) of the Andalusia Member.

Strata of the "upper" Andalusia Member (Fig. 4, units 11-16) consists of thick-bedded and massive dolomites interbedded with shaley biostromal units in the lower part (Fig. 4, units 11-15b) and contain low to moderate diversity brachiopod assemblages (Figure 6). James Hall (1858) and Stainbrook (1943a) collected *Orthospirifer capax* from units of the upper Andalusia. The *Orthospirifer* Fauna of the Andalusia was first described by Day (1989a), and later (Day, 1992) divided into distinct lower and upper parts.

The lower part of the *Orthospirifer* Fauna is characterized by the assemblages from the "biostromal" wackestones and packstones of units 11-15b of Figure 4 (samples 16-22 in Fig. 6). The most abundant brachiopod in this interval is the medium sized strophomenid *Strophodonta* (*S.*) *callawayensis*, with smaller numbers of *Orthospirifer capax, Independatrypa scutiformis,* large *Schizophoria athabaskensis, Cyrtina* sp. A., *Athyris vittata, Allanella annae, Cranaena* n. sp., rare *Hadrorhynchia solon,* locally abundant and diverse orthoconic and cyrticonic nautiloid cephalopods, and large infaunal *Paracyclus rowleyi* (unit 11 of Fig. 4). The solitary tetracoral *Tabulophyllum callawayense* is abundant in units 11-14 of the Andalusia Member (Fig. 4). Small, well-preserved, archaeogastropods also occur in this interval (Figs. 4 and 6) and are assigned to *Elasmonema.* The upper part of the *Orthospirifer* Fauna is characterized by the occurrence of locally abundant moldic specimens of *S. callawayensis* with echinoderm debris at the Lafarge Corporation Quarry (Figs. 4, 6, samples 24-27).

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PALEOBOTANY OF PENNSYLVANIAN CHANNEL FILLS AT ALLIED QUARRY

Richard L. Leary
Illinois State Museum
1011 E. Ash St.
Springfield, IL 62703

INTRODUCTION

Probably the most striking feature of this quarry is the presence of a number of channels and caves that developed in Devonian strata. These features must have formed after the end of Mississippian deposition because they contain no sediments of Mississippian age. On the other hand, they must have existed before widespread Pennsylvanian sedimentation began in this area, for the sediments filling them are among some of the oldest-known Pennsylvanian strata in the state. These Pennsylvanian rocks occur stratigraphically lower than the Pennsylvanian layers at a neighboring borrow pit and across the Rock River at Black Hawk State Park. The solution features strongly suggest that this area was topographically high — part of the Mississippi River Arch — when they were formed.

The basal Pennsylvanian deposits in this quarry have been the major source of plant fossils representing Early Pennsylvanian "upland" floras in Illinois. Although now largely removed by quarrying operations, some fossil-bearing channel deposits can be seen, and plant fossils can be collected.

The plant fossils occur in the shale and mudstone that fill elongate depressions (channels) eroded in the Middle Devonian Cedar Valley Limestone. The channels are 4 m to 6 m deep and 8 m to 20 m wide. One channel can be seen in cross section at the top of the north wall, at about mid-quarry.

Channel deposits similar to those exposed in the Allied Quarry were also observed in the Cleveland and Midway quarries in eastern Rock Island County (Fig. 1). It is likely these were all part of a river

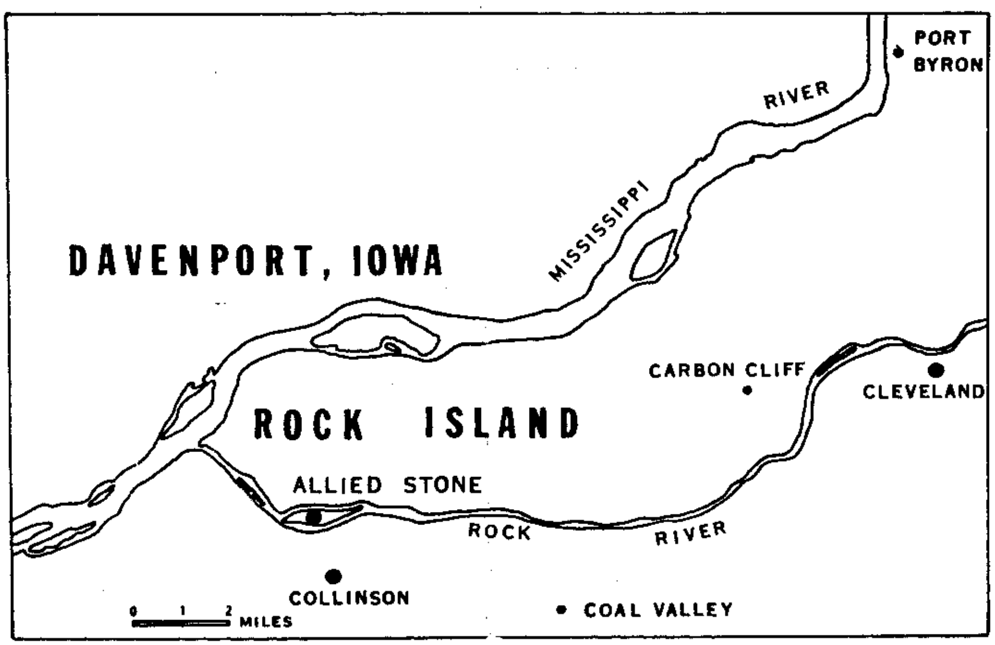


Figure 1. Map of the Rock Island County, Illinois, area showing locations of other sites where Early Pennsylvanian strata have been observed.

which flowed from the east-northeast to the west-southwest between a series of low hills (Leary, 1981). It is possible that these channels represent an incision of a distributary channel of the Michigan River which crossed Michigan, Indiana, and portions of Illinois before emptying into the sea.

Several animal fossils have been found associated with the plant fossils in the Allied Quarry. These include a fossil scorpion (*Labriscorpio alliedensis* gen. & sp. nov., Leary 1980a), two small fish jaws, several fish scales, and numerous fragments of arthropods(?).

ALLIED STONE COMPANY QUARRY FLORAS

Overall, plant fossils within the channel fills can be divided into two separate floras. The presence of these two distinct floras is significant from a paleoecological viewpoint, providing evidence that floral differences are environmental and not just age-controlled. A diverse flora, dominated by *Megalopteris* and *Lesleya*, occurs in the lower gray shale/mudstone. A second flora, which occurs in black fissile shale at the top of the channels, contains abundant *Mesocalamites* and lycopods, and little else. This latter flora is similar to Early Pennsylvanian coal swamp floras.

These floras are among the oldest Pennsylvanian floras known in the Illinois Basin (see Jennings, 1974, 1975), and certain differences in composition between these floras and normal coal-swamp floras reflect changes through time. The relative abundance of various taxa (Table 1) has been estimated.

The earlier of the two floras preserved in the Allied Stone Company Quarry, which occurs in gray shale and mudstone, is remarkable with respect to its mode of occurrence, its age, the plants represented, and their abundance. As indicated by enclosing sediments and associated paleotopography, this flora did not grow in a lowland environment.

The abundance of *Megalopteris, Lesleya,* and *Cordaites* is impressive. Lycopsids and pteridosperms, abundant in lowland floras preserved in shales overlying coals ("roof shale"), are here subdominant to rare. In contrast, the Noeggerathiales, present in fairly large numbers here, are absent in lowland floras. Some portions of these deposits contain exclusively or primarily one or a few genera (e.g., *Sphenopteris* or *Megalopteris* predominate on some bedding planes).

The flora of the upper black shale is distinct from that of the lower gray shale and corresponds to Early Pennsylvanian coal- swamp floras. The change from a *Megalopteris*- and *Lesleya*-dominated flora to one dominated by *Mesocalamites* and lycopods, coinciding with a change from gray shale and mudstone to black fissile shale, is evidence for environmental control of floral composition.

HISTORICAL PERSPECTIVE

Several occurrences of Early Pennsylvanian (Late Namurian-Early Westphalian) plant fossils in western Illinois have been known since the late 1800s (Worthen, 1873). In 1907, David White (1908) examined fossils from several localities in this area and published a brief report with a list of 14 fossil plant genera. Between 1907 and 1975, only sporadic collecting was done. Extensive collecting was done by the author between 1975 and 1991. The only significant collections known are those at the Illinois State Museum. Compression plant fossil studies in the area of the Illinois Basin are reviewed by Phillips, Pfefferkorn, and Peppers (1973).

SIGNIFICANCE

Although fossil floras from upland situations are rare and little known, they occupied environments considered to be the location of major advances in plant evolution (see Frederiksen, 1972, for summary). Evolution is thought to have progressed more rapidly in variable upland environments than in swamps and lowlands (Upshaw and Creath, 1965; Krasilov, 1969; Tiffney and Knoll, 1979). However, this idea has been disputed, at least with regard to angiosperms (Hughes, 1974; Retallack and Dilcher, 1979). Phillips (1979) and

Table 1. List of genera present at the localities in Brown and Rock Island counties, Illinois. Based upon approximately 350 specimens from Brown County and 1,000 from Rock Island County.

Approximate abundance indicated by the following: vr = very rare, r = rare, c = common, a = abundant

Genera	Abundance: Brown County	Abundance: Rock Island County
Lycophytina		
Lepidodendron	vr	c
Lepidophloios		vr
Lepidophyllum		c
Lepidostrobu		c
Lepidostrobphyllum		c
Lepidocarpon		c
Stigmaria		vr
Sphenophytina		
Mesocalamites	c	c
Asterophyllites	c	c
Annularia	c	
Calamostachys	c	c
Sphenophyllum		r
Filicophytina (Ferns)		
Alloiopteris	c	r
Dactylotheca	vr	
Pteridosperms		
Alethopteris	c	c
Sphenopteris	a	c
Lagenospermum	vr	c
Telangium	c	r
Megalopteris	c	a
Lesleya	c	a
Samaropsis	c	a
?Neuropteri		vr
?Mariopteris	vr	vr
Whittleseya		vr
Aulacotheca		vr
Rhodea	r	vr
Rhodeopteridium	vr	?
Noeggerathiales		
Lacoea	a	c
Palaeopteridium	c	r
Gulpenia	r	vr
Cordaitales		
Cordaites	c	a
Cardiocarpus	r	c
Cordaianthu		r
Artisia		r

Peppers (1979) have shown that seed-bearing plants (*Cordaites* and pteridosperms) evolved outside of the coal swamps and subsequently migrated into swamps in Middle and Late Pennsylvanian. The tree-fern *Psaronius*, which was found in the Allied Stone Company Quarry, also originated on uplands and later moved into coal swamps (DiMichele and Phillips, 1977).

DESCRIPTION OF SIGNIFICANT "UPLAND" TAXA

The term "upland" has been used to designate distinctive nonswamp floras, but the actual paleoecology of such floras is not known. The "upland" plants grew on soils derived from limestone bedrock in western Illinois, and many were near stream banks and ultimately were deposited in stream channels with minimal transport.

Because the "upland" flora includes a number of genera that are not found in coal swamps and are not well known, some general descriptions and illustrations are given.

Several species of *Megalopteris* occur in the floras of western Illinois. These range from large trilobed *M. dawsoni* (Hartt) Andrews (Pl. 1, Fig. 1) to smaller, pinnate (alethopteroid) forms such as *M. ovata* Andrews (Pl. 2, Fig. 1). Other specimens (Pl. 2, Fig. 2) that probably belong to the megalopteroid group, if not to the genus *Megalopteris*, are similar to published figures and descriptions of such genera as *Neriopteris* (Newberry, 1873), *Orthogoniopteris* (Andrews, 1875) and *Protoblechnum* (Andrews, 1875). Differences between these genera and their relationships are not clarified in the literature.

Lesleya foliage is similar to *Megalopteris* pinnules, but consists of simple leaves (Pl. 1, Fig. 2). These leaves are up to 60 cm long and 10 cm wide, although most specimens are less than 30 cm long. The midvein is broad, although not as broad as that of *Megalopteris*; the lateral veins are curved and divide once, twice, or three times. *Lesleya* and *Megalopteris* are also separated on the basis of epidermal structures (Florin, 1933).

Early forms of *Glossopteris* (i.e., *G. wilsonii* of Argenitina and *G. communis* of Brazil) are similar to *Lesleya*. These early forms have few or no anastomosing secondary veins. *Lesleya* has been suggested as an ancestor of *Glossopteris* (Leary, in press).

Mesocalamites (Pl. 3, Fig. 1) is distinguished from *Calamites* on the basis of the continuity of ribs across the nodes. *Calamites* ribs alternate; whereas some ribs of *Mesocalamites* alternate, and some are continuous. *Mesocalamites* is largely restricted to the Namurian, rarely extending into the Westphalian. *Archaeocalamites*, an older form, has all ribs continuous across the nodes. The correlation of various species of *Mesocalamites*/*Calamites* to the species of *Asterophyllites*/*Annularia*, and to fructifications, *Calamostachys*, is still not complete.

Lacoea (Pl. 3, Fig. 5) is a cone consisting of semicircular sporophylls that alternate on a thick axis. One spore-bearing specimen was found in the Allied Quarry (Leary, 1980b). *Lacoea* and similar, perhaps synonymous, forms are known from a few far-distant localities: Holland (Hirmer, 1940, 1941); Belgium (Stockmans and Williere, 1962); Czechoslovakia (Feistmantle, 1879); Germany (Hirmer, 1940); and China (Stockmans and Mathieu, 1957). Although Read (1946) suggested that *Lacoea* might be a pteridosperm, specimens from Brown County, Illinois, permitted a reinterpretation: *Lacoea* is now considered a member of the Noeggerathiales (Leary, 1973). However, the broader natural affinities of the Noeggerathiales are not known. This order has been treated as a separate group or loosely allied with either the Pteridopsida or Sphenopsida (Boureau, 1964). The Noeggerathiales are well represented in the upland floras of western Illinois.

Gulpenia (Pl. 3, Fig. 2), another member of the Noeggerathiales, is characterized by small, deeply lacerated leaves attached spirally to a thin axis. In compression, *Gulpenia* bears a superficial similarity to *Sphenophyllum* (Pl. 4, Fig. 4), but the leaves clearly are not in whorls.

A variety of enigmatic fossil plants occur in this flora (Leary, 1993). The presence of unusual plants of unknown affinity is consistent with the idea that evolution occurred primarily on uplands.

Megalopteris is not known to occur outside North America (Arnold, 1934)* where it has been reported from the following localities: St. John,

PLATE 1

Plate 1. Fig. 1. *Megalopteris dawsoni* X .5, Fig. 2. *Lesleya cheimarosa* X .5.

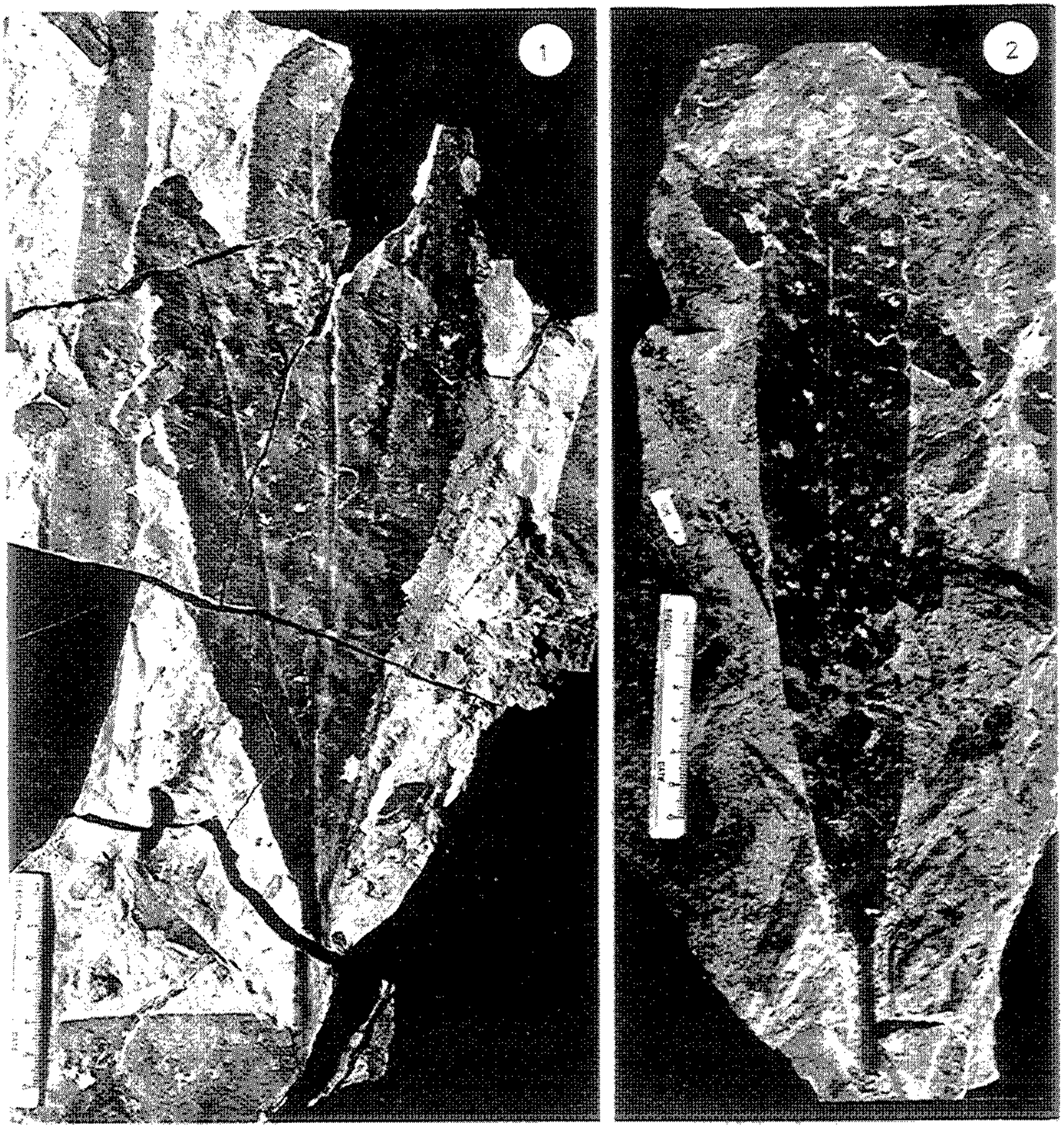


PLATE 2

Plate 2. Fig. 1. *Megalopteris ovata* X 1. Fig. 2. *Megalopteris ovata*? X 1.

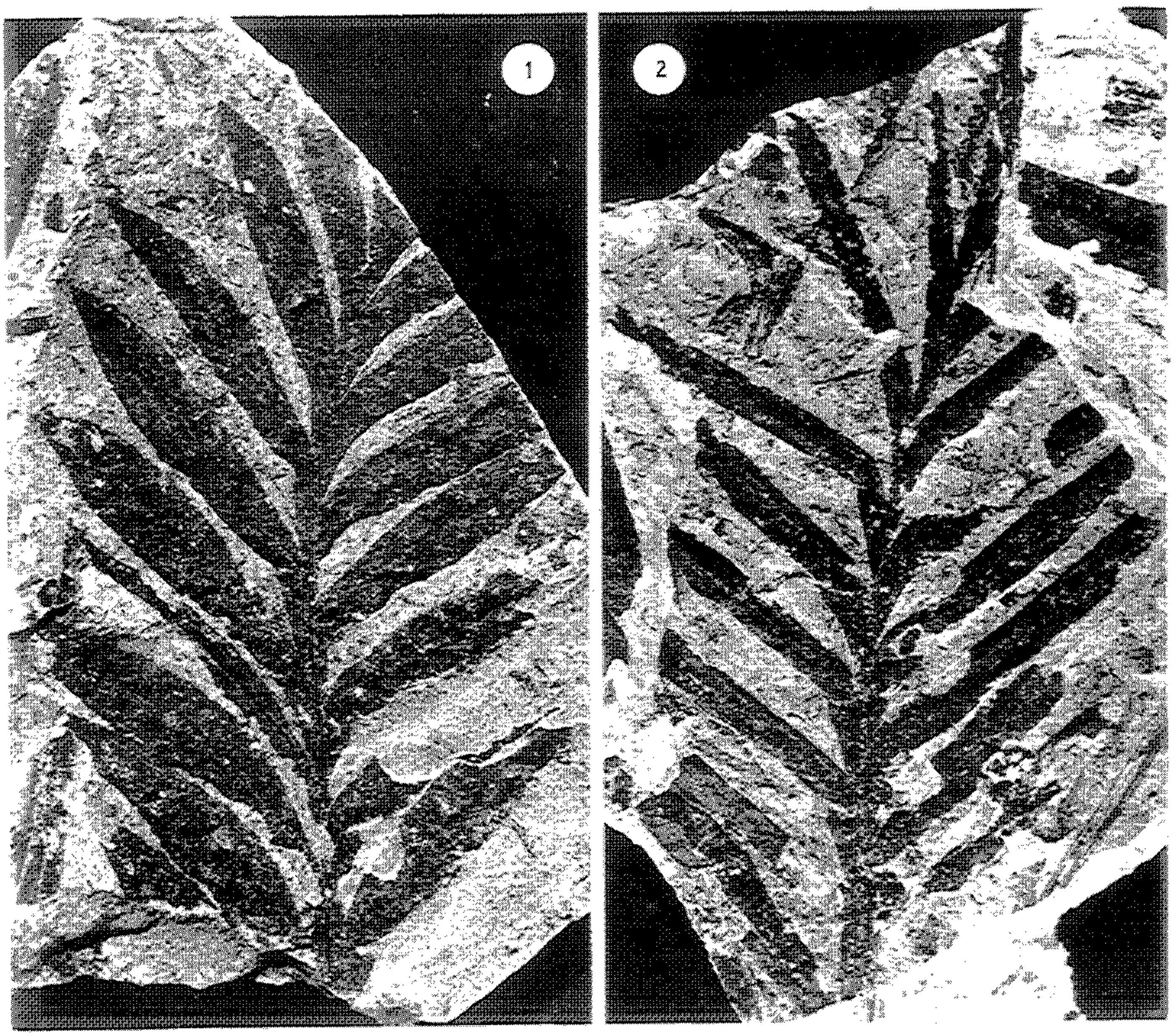


PLATE 3

Plate 3. Fig. 1. *Mesocalamites* sp. X 1. Fig. 2. *Gulpenia* sp. X2. Fig. 3. *Samaropsis newberryi* X 1. Fig. 4. *Sphenophyllum tennerrimum* X 1. Fig. 5. *Lacoea seriata* X 1. Fig. 6. *Sphenopteris* sp. X 1. Fig. 7. *Mariopteris* sp. X 1.

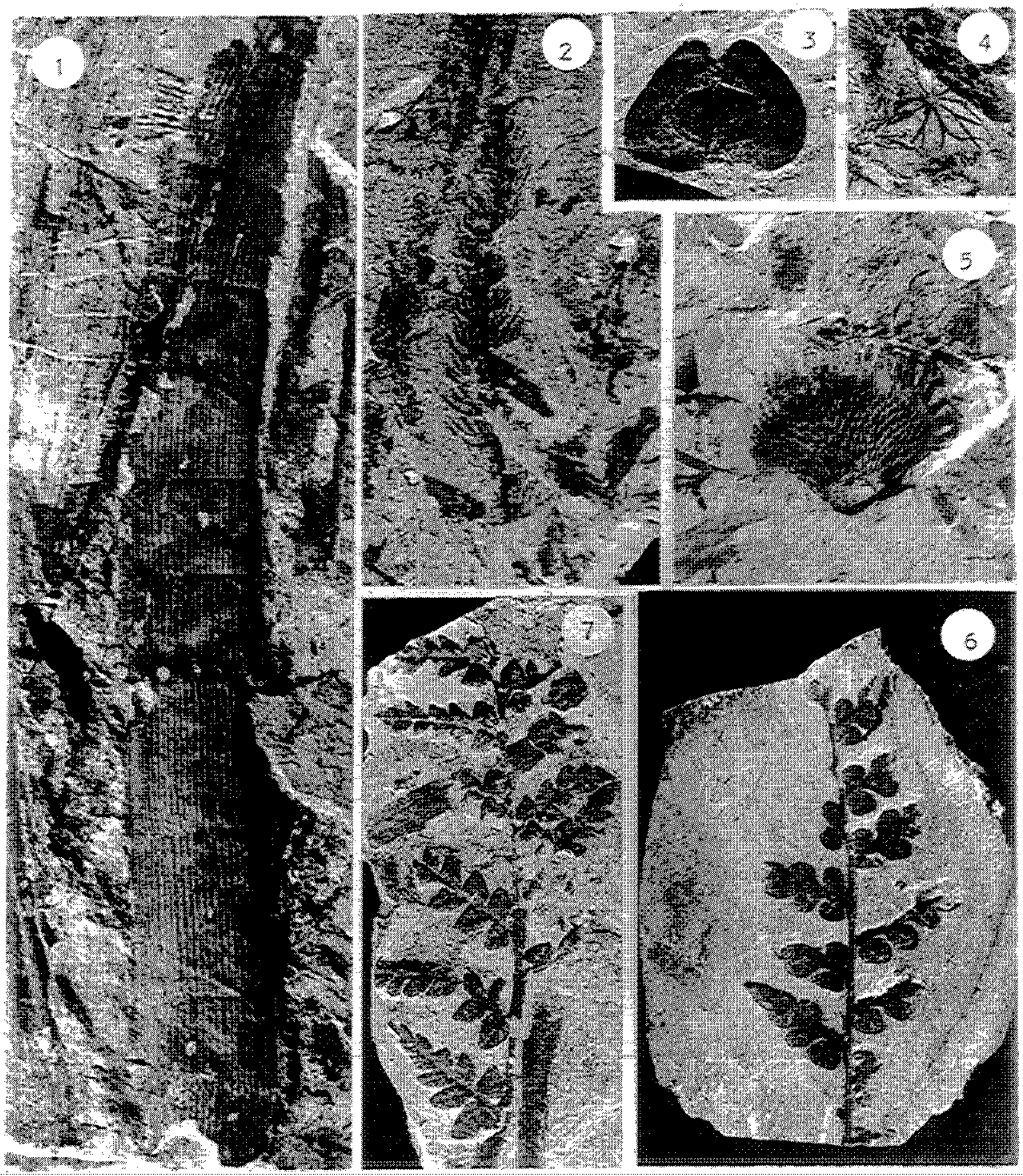
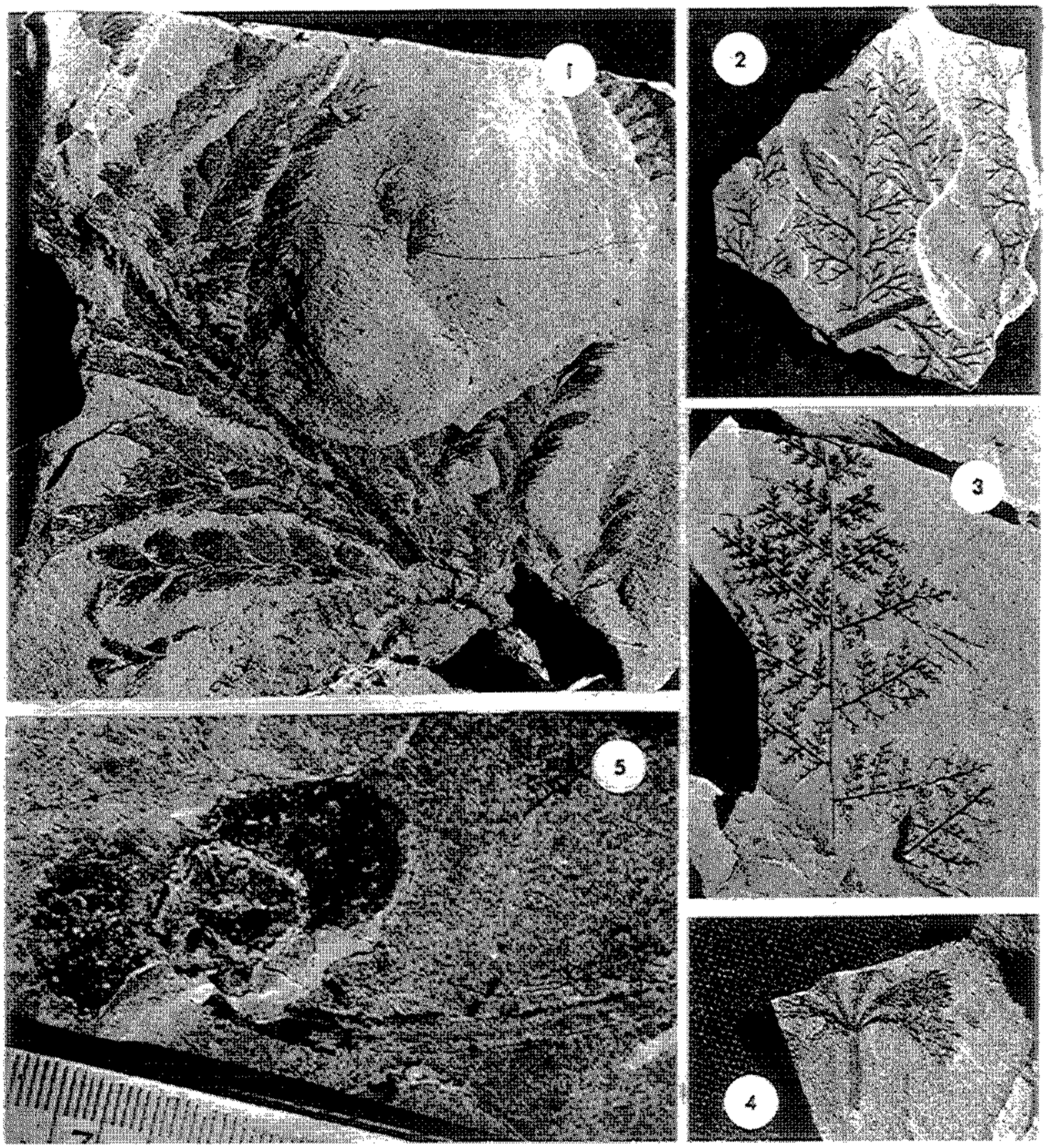


PLATE 4

Plate 4. Fig. 1. *Palaeopteridium reussii* X 2. Fig. 2. *Sphenopteris* sp. X 1. Fig. 3. *Sphenopteris* sp. X 1. Fig. 4. *Sphenophyllum cuneifolium*? X 2. Fig. 5. *Samaropsis newberryi* X 1.



New Brunswick, Dawson (1871), Stopes (1914); Rushville, Ohio, Andrews (1875); Cross (1962); East Liverpool, Ohio, McComas (1988); Port Byron, Illinois, Lesquereux (1880); Wyoming Hill, Iowa, Noe (1925); Grand Ledge, Michigan, Arnold (1934); Saginaw, Michigan Arnold (1934); Putnam County, Indiana, Arnold (collected 1936, oral comm.); Pictou, Canada, Bell (1940); West Virginia, White (1913); Greene County, Indiana, Canright (1959), Wood (1963); Brown County, Illinois, Leary and Pfefferkorn (1977); Rock Island County, Illinois, Leary (1974b, 1976).

In almost half of these localities, *Megalopteris* occurs with a flora that is distinct from the common coal-swamp flora. The *Megalopteris* floras appear to contain greater percentages of pteridosperms and *Cordaites* and smaller percentages of ferns and lycopods than do Early Pennsylvanian floras associated with coal seams ("swamp floras") (Phillips et al., 1974). White (1931, pp. 275-276) suggested that *Megalopteris* and *Lesleya* are unique to upland soils developed on carbondates. Recent studies by Cross (pers. comm.) supports this concept. The flora associated with *Megalopteris* apparently grew on drier uplands underlain by limestone.

Environmental changes indicated in the Allied flora

Studies of the paleoecological differences in Mississippian-Pennsylvanian floras have shown that several paleoenvironments can be recognized (Peppers and Pfefferkorn, 1970, for summary; also Remy and Remy, 1977). At the top of the channel fill sequence in the Allied quarry, the flora is characterized by an overwhelming abundance of *Mesocalamites* with *Lepidodendron* (Pl. 5, Fig. 2) and *Psaronius*; little else is present. This change in composition apparently represents a change from drier "upland" to wet lowland or swamp conditions, as stream channels were filled with sediment and the water table correspondingly rose to near ground level. Tenchov (1976) described floral changes within a Carboniferous floral sequence of western Bulgaria and related these to continuous uplift of the basin. Changes in the elevation of the western margin of the Illinois Basin, relative to the central area of the Basin, may have brought about changes in floral.

COMPARISONS OF "UPLAND" FLORAS

Recent studies of an Early Pennsylvanian flora from Brown County, Illinois (Fig. 2) (Leary, 1973, 1974a, 1974b, 1976; Leary and Pfefferkorn, 1977) have identified 21 genera of plants (Table 1). Among the most common are *Lacoea*, *Sphenopteris*, *Cordaites*, and *Alethopteris*. *Megalopteris* and *Lesleya* are also well represented. Thirty-two genera of foliage, fructifications, and stems have so far been identified from the Allied Stone Company quarry (Table 1). The most abundant taxa at this site are *Megalopteris*, *Lesleya*, *Samaropsis*, *Cordaites*, and *Cardiocarpus*.

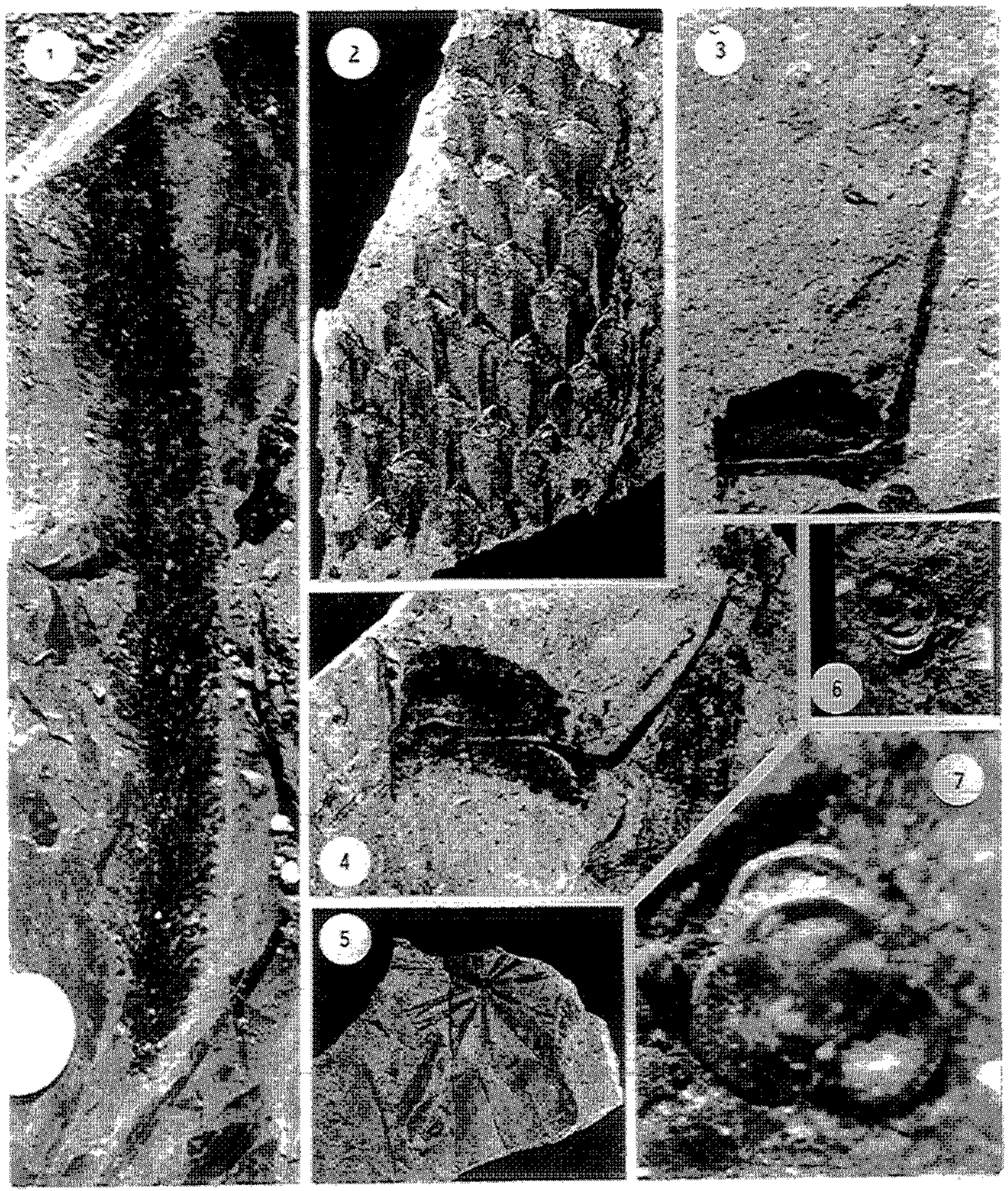
The two floras (Table 1) have many genera in common; differences are in the relative abundance of certain genera and presence or absence of certain others. Arborescent lycopods are common in the Rock Island flora but very rare in the Brown County flora; only one determinable specimen and two fragmentary specimens of *Lepidodendron* have been found at the latter site. Lycopods are the dominant plants in most Lower and Middle Pennsylvanian coal swamp floras of the Illinois Basin (Phillips et al., 1974). Sphenopsids and cordaites are more abundant in parts of the Rock Island flora than in the Brown County flora; ferns are more common in the Brown County flora. Although the ages of the two floras are probably not exactly the same, the differences in generic composition probably reflect environmental differences rather than age differences. In Rock Island, the presence of a permanent body of water in the channels and low, moist areas adjacent apparently permitted the growth of such genera as *Lepidodendron* and *Mesocalamites* on the overall drier sites, even though these plant types are commonly associated with coal swamp environments.

INTERPRETATION

Each Early Pennsylvanian flora of the Rock

PLATE 5

Plate 5. Fig. 1. *Lepidostrobus* sp. X .75. Fig. 2. *Lepidodendron* sp. X 1. Fig. 3. *Lepidocarpon* sp. X 2. Fig. 4. *Lepidocarpon* sp. X 2. Fig. 5. *Sphenophyllum* sp. X 1. Fig. 6. *Triletes auritus* tetrad X 5. Fig. 7. *Triletes auritus* tetrad X 15.



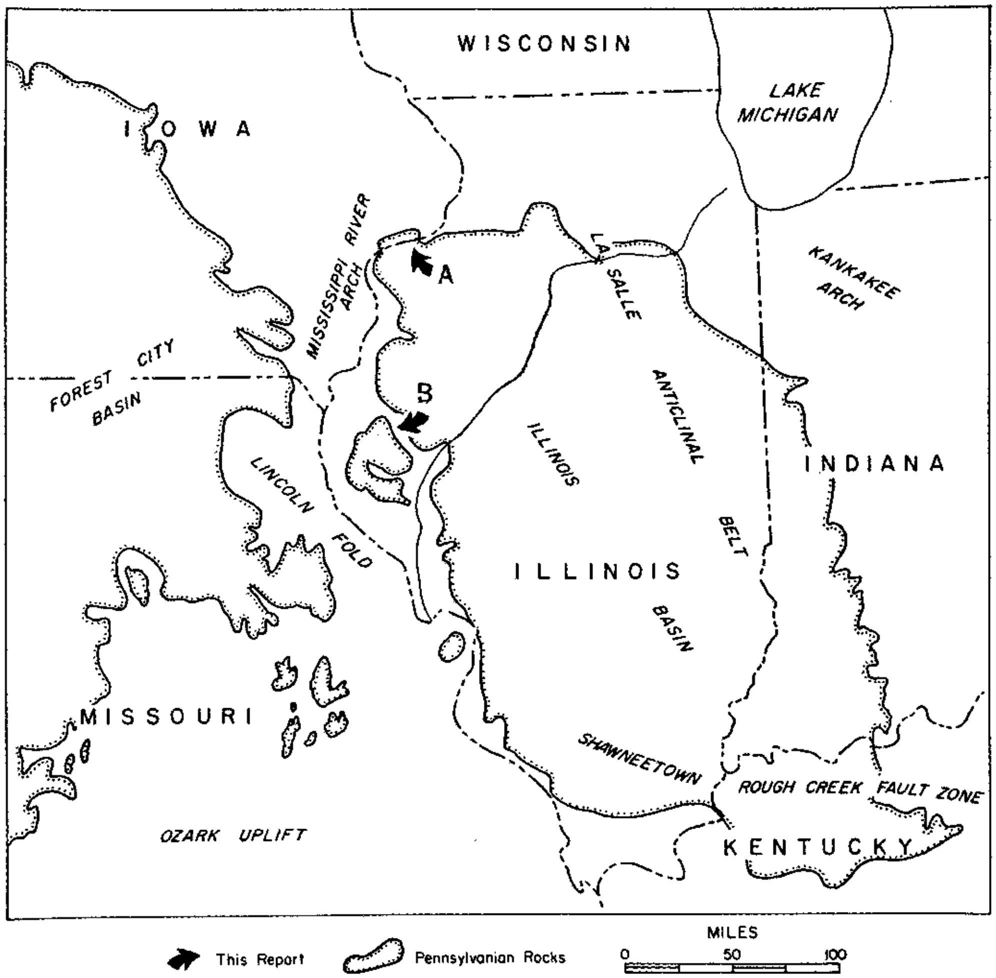


Figure 2. Map showing relation of the areas mentioned (Rock Island and Brown counties) to regional structural features. Base map courtesy of the Illinois Geological Survey.

Island County area (Allied, Midway, Cleveland, and Milan Stone quarries) differs from the others to varying degrees, and most differ from a "typical coal-swamp flora" (Leary, 1981). The latter floras are characterized by an abundance of lycopods (*Lepidodendron, Lepidophloios*, and/or *Sigillaria*) and sphenopsids (*Calamites*)(Peppers and Pfefferkorn, 1970; Oshurkova, 1977; and Scott, 1977). Pteridosperms (e.g., *Neuropteris* and *Alethopteris*) grew elsewhere in such lowland settings as levees and floodplains (Peppers and Pfefferkorn, 1970; Oshukova, 1977; Scott, 1977).

Composition of the black shale flora from the upper part of the Allied Stone Company Quarry channel corresponds to that ofEarly Pennsylvanian coal-swamp floras. Although lycopods occur in most other Early Pennsylvanian floras of the Rock Island County area, certain pteridosperms (notably *Neuropteris* and frequently *Alethopteris*) are absent here. On the other hand, those pteridosperms (e.g., *Megalopteris* and *Lesleya*) that are abundant in several floras in the area, are not known from coal swamp or lowland floras. The same is true of the Noeggerathiales (*Lacoea, Palaeopteridium*, and

Gulpenia), that also occur here.

White (1931) suggested that *Megalopteris* and *Lesleya* are unique to uplands developed on carbonates. Studies by Cross (personal communication) support this concept. This facies dependence was given insufficient consideration when Read and Mamay (1964) established their Upper Paleozoic zonation of the United States. Although they stated (1964:K8) that "the species of *Megalopteris* seem to be most abundant where Pennsylvanian strata of Early Atoka age occur immediately above pre-Pennsylvanian karst surfaces," they limited the "zone of common occurrence of *Megalopteris*," Zone 7, to the base of the Atokan Series (basal Westphalian B), excluding possible older occurrences immediately above pre-Pennsylvanian karst surfaces.

Studies of Mississippian-Pennsylvanian floras have shown that several paleoenvironments can be recognized (Peppers and Pfefferkorn, 1970; Remy and Remy, 1977, for summary). Several distinct environments probably are represented by floras described herein. The "upland floras" dominated by *Megalopteris* and *Lesleya* and containing Noeggerathiales and *Cordaites* grew on well-drained uplands, perhaps no more that 5 m above local base level. Normally, the uplands were underlain by carbonates that permitted well-drained soils to develop and that provided terra-rossa-type soils.

In some areas, nearness to water permitted growth of more hygrophilous plants adjacent to the channels eroded within a nearly flat limestone paleosurface. Here lycopods and *Mesocalamites* grew with *Megalopteris* and *Lesleya*.

As the sea advanced, channels and valleys were filled and the water table rose; floras were dominated by lycopods and *Mesocalamites*. *Cordaites* grew in each of these environments, although early in this sequence they were more abundant in upland floras. During fluvial/deltaic stages, lycopods, *Mesocalamites*, and certain sphenopterids (vines?) were abundant. Some of these may have been the earliest colonizers of sandy and muddy near-shore environments during the Early Pennsylvanian.

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RECLAMATION OF A SPOIL PILE AT MOLINE CONSUMERS COMPANY, ALLIED STONE QUARRY

Greg Castrey
Moline Consumers Co.
Moline, Illinois

Quarrying operations began on Vandruffs Island in 1958. The Island is an ideal locality for a quarry because of the high quality limestone and dolomite present in the subsurface, the lack of thick unconsolidated overburden, and being situated within a large population center. Moreover, the Rock River acts as a natural buffer between the quarry and surrounding residential areas. Allied Stone Quarry supplies high quality construction and agricultural crushed stone material to a large market area that includes: the Quad-Cities area, Western Rock Island County, Mercer County, McDonough County, Henderson County, and Warren County. Uses for the crushed stone aggregates includes crushed stone for: Portland cement, bituminous concrete, base coarse for roadways, and rip-rap for armoring levees. Fine aggregates are are used for manufactured sand and agricultural lime. During the summer of 1994 Allied Stone will supply aggregate for construction on several sections of Illinois Route 67 between Milan and Macomb.

In the course of mining Devonian and Silurian carbonates numerous pockets of unsuitable Pennsylvanian aged shale, siltstone, and sandstone, as well as unconsolidated clay, sand and gravel must be removed. All of the above, with the exception of sand and gravel are deleterious for concrete and bituminous aggregate.

The shale pockets (Pennsylvanian karst and channel fills) are first drilled and blasted, then loaded onto trucks and hauled to the east end of the Island. When the spoil pile reached 15 feet in thickness and crested the trees along the river bank, residents living on the north end of the island complained. At this point a revegetation project was initiated. First the waste pile was covered with 4 to 6 feet of unconsolidated overburden consisting of clay, soil, sand and gravel. Revegetation was attempted the following Spring. A pasture mix of 55% alfalfa (*Medicago sativa*), 15% Kentucky blue grass (*Poa pratensis*), 15% perennial rye grass (*Secale cereale*) and 15% red fescue (*Festuca rubra*) was planted at a rate of 50 pounds per acre. Some of the sandier areas were naturally recolonized by sweet clover (*Melilotus alba*). Black locust trees (*Robinia pseudo-acacia*) were planted with a 5 X 5 foot spacing. Other native trees naturally recolonizing the spoil pile include: black locust, silver maple (*Acer saccharinum*), sycamore (*Platanus occidentalis*), and cottonwood (*Populus deltoides*).

The revegetation project has been a success and the south end of Vandruffs Island is home to a variety of wildlife. White-tailed deer, woodchucks, raccoons, eastern cottontails, and Red fox are commonly observed. Additionally, falcons (American Kestrel) make their home in the highwall on the north side of the quarry and large numbers of Great Blue Herons roost at the south end of the quarry.

Recently, a new spoil pile was started on the southeast side of the island, this new pile cannot be seen by residents and revegetation has yet to be initiated.

STOP DESCRIPTIONS AND DISCUSSIONS

William Hickerson and Richard Anderson
Department of Geology
Augustana College
Rock Island, IL

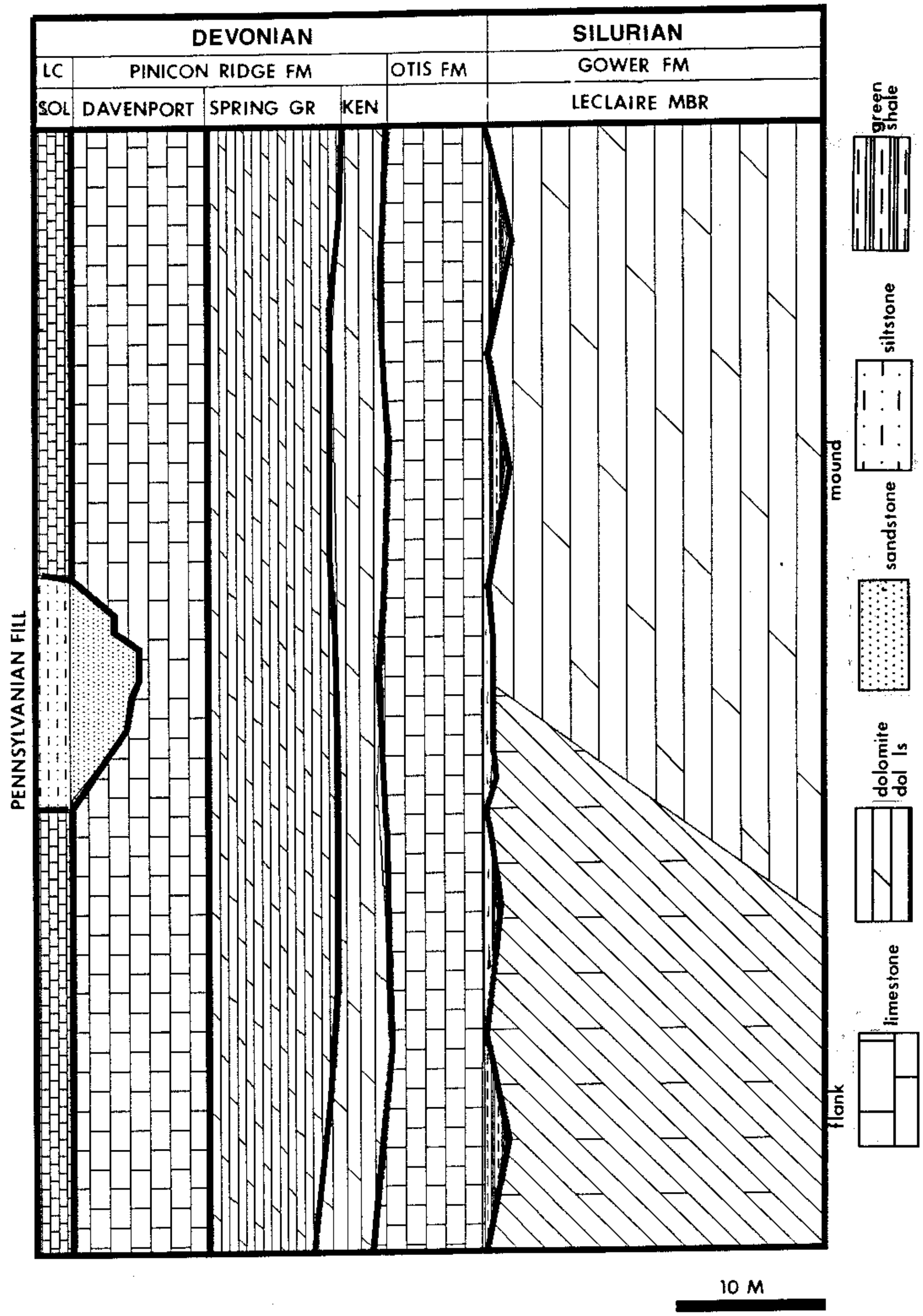


Figure 1. Generalized depiction of the north highwall at Allied Stone Quarry.

STOP 1. Allied Stone Quarry-SE 1/4, Sec. 14, T. 17 N., R. 2 W.,
Rock Island, Rock Island County, Illinois.

The highwall on the north side of the quarry exposes a section of > 20 m of the Silurian Gower (Racine) Formation, the entire Wapsipinicon Group, and basal Little Cedar Formation (Fig. 1). Pennsylvanian channel fills preserving an abundant flora (Leary, *this guidebook*) are present, but not well exposed at this time.

Fossil collecting is excellent in the Silurian at this locality, which is developed in mounded facies of the LeClaire Member. (Witzke, *this guidebook*). Crinoid (*Eucalyptocrinites*, *Siphonocrinus*) and rhombiferan cystoids (*Caryocrinites*, *Megacystites*) calices are commonly associated with tabulate (*Favosites*) and solitary rugose corals, stromatoporoids, brachiopods, fenestellid bryozoans, nautiloids (coiled and straight), gastropods, and trilobites (*Bumastus ioxus*, *Calymene niagarensis*, *Cheirurus* sp.).

Otis Formation lithologies at this locality are stylolitic, thin-bedded, fine-grained pure limestones. The small, thin-shelled brachiopod *Emanuella* is common to abundant (see Day and Koch, *this guidebook*).

The Solon Member is interesting at this locality. At the north ramp section the lower 1 m of Solon consists of thin-bedded, fine-grained, sparsely fossiliferous calcarenite. Approximately 300 m south on the upper bench, the lower 1 m of Solon is coarser grained, thicker bedded and contains a highly diverse and abundant fauna, with tabulate corals (*Favosites*), bulbous stromatoporoids, inadunate crinoids, and atrypid brachiopods (*Independatrypa independensis*, *Spinatrypa*). At this site slabs preserving groups of complete trilobites (*Phacops iowensis iowensis*), articulated inadunate crinoids, blastoids (with brachioles), and a cranium of a large (> 3 m in total length) arthrodire placoderm, *Eastmanosteous* were recovered. The upper Solon Member is dominated by coral/stromatoproid biostromes. Upper Solon fossils include colonial rugose corals (*Phillipsastrea, Hexagonaria*), branching tabulates (*Thamnopora*), massive stromatoporoids, sponges (*Astreospongia*), brachiopods (*Cranaena*, *Pentamerella*, *Orthospirifer*), rostroconchs, gastropods (bellerophonids, platycerids), nautiloids (*Centroceras*, *Acleistoceras*?), ostracodes, and trilobites (*Phacops rana*?, *Dechenella*? *prouti*, *Crassiproetus* sp., and *Mystrocephala pulchra*).

The basal Rapid Member is exposed on the upper bench. Rapid Member lithologies differ from the underlying Solon Member in being finer-grained, more argillaceous, and generally lacking colonial rugose corals and stromatoporoids. Faunally, the Rapid Member is dominated by brachiopods (*Spinatrypa bellula, Orthospirifer iowensis, Schizophoria iowensis*) and bryozoans (many taxa), with solitary rugose corals, crinoid debris, sponges, gastropods (several platycerids), nautiloids, and fish debris. Trilobites collected at this locality include: *Phacops norwoodensis*, *Greenops* sp., *Neometacanthus barrisi*, and *Crassiproetus occidens*.

STOP 2. Milan Stone Quarry (Collinson Brothers)-NW1/4, Sec. 25, T. 17 N., R. 2 W., Milan, Rock Island County, Illinois.

Milan Stone Quarry (MSQ) along with natural outcropings and an abandoned quarry along adjacent Mill Creek expose the most complete Middle Devonian section in Northwestern Illinois. The Otis, Pinicon Ridge, and basal Little Cedar formations are exposed within the quarry (Fig. 2) and the entire Little Cedar Formation (Fig. 3) as well as the Cou Falls Member of the Coralville Formation are well exposed along the creek. The Mill Creek section has been studied by Devonian workers for nearly 100 years (Udden, 1897; Udden and Savage, 1923; and Collinson, 1966). More recently, a diverse trilobite fauna (Hickerson, 1992 and 1994) from the Little Cedar Formation and ptyctodontid fish (*this guidebook*) from the Pinicon Ridge Formation have been described from this quarry and adjacent exposures.

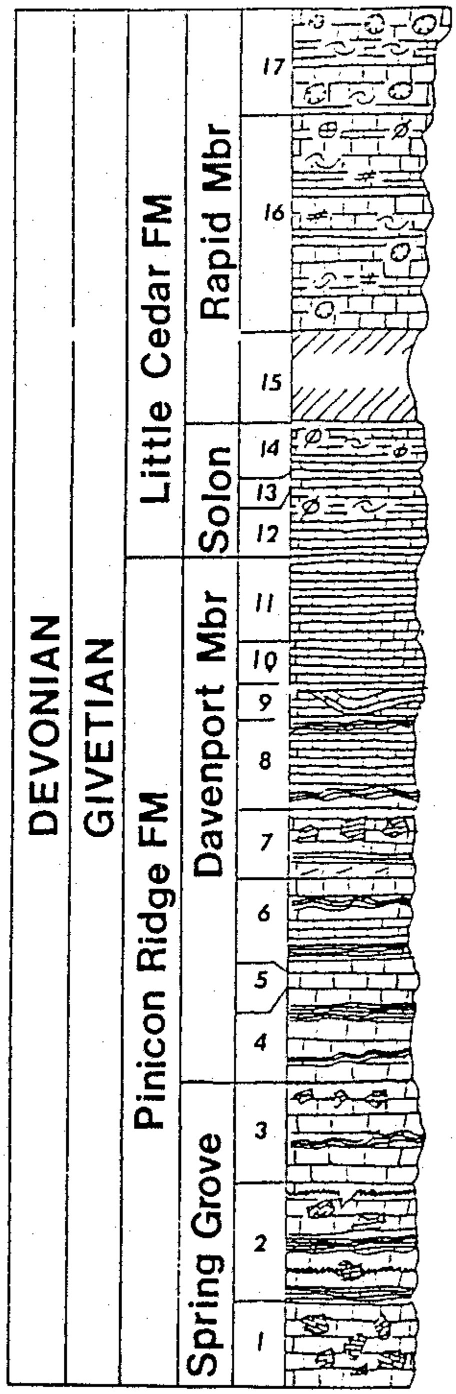
The Racine Formation (Gower Formation, LeClaire Member) has been recently exposed in the deepest part of the quarry. Fossils are not as common or as well preserved in the Silurian dolomite here as they were at Stop 1 (Allied Quarry). Stromatoporoids, rynchonellid brachiopods, and crinoid debris are common.

At MSQ the Otis Formation differs considerably from equivalent strata at Stop 1. Here the Otis is thin, approximately 3 m thick, coarsely crystalline in nature, and apparently lacks the distinctive brachiopod *Emanuella*. At Allied Quarry the Otis is approximately 8 m thick, composed of fine-grained, stylolitic limestone with common to abundant *Emanuella* (Day and Koch, *this guidebook*). The difference in thickness and lithology is related to the differential deposition on the underlying post-Silurian erosion surface.

The Kenwood, Spring Grove, and Davenport members of the Pinicon Ridge Formation are well exposed. Kenwood lithologies include argillaceous dolomite, green shale, chert and breccia. Fossils are not known from the Kenwood. The Spring Grove Member has produced a well preserved fish fauna at this locality (Hickerson, *this guidebook*). Davenport Member lithologies include sublithographic limestone, pelloidal calcilutites, laminated calcilutites, and limestone breccia (Fig. 2). Stromatolites and ostracodes are common at some horizons and fish debris was noted on one bedding plane. The Pinicon Ridge Formation was deposited in a shallow, hypersaline, restricted circulation environmental setting.

On the upper bench (east side) highly fossiliferous limestones of the Solon and Rapid members of the Little Cedar Formation are well exposed. Of particular interest are bedding plane exposures of the lower Rapid Member. Brachiopods (Day, *this guidebook*), bryozoans, solitary rugose corals, trilobites and other invertebrates have been collected in large numbers here. Articulated trilobites are present in the lower 2 m of the Rapid Member and groups of trilobites (2-20 specimens) including *Phacops norwoodensis*, *Greenops* sp., *Crassiproetus occidens*, and *Crassiproetus* sp. have been collected (Fig. 3) at this locality.

Pennsylvanian paleocarst features are present within the Devonian carbonates at various stratigraphic levels. A variety of lithologies are present within these features. Small joints and crevices are generally filled with dark shale, larger karst features are filled with laminated siltstone and fine-grained sandstone with carbonaceous partings. A large cavity at the northeast corner of the quarry is filled with siltstone, sandstone, and conglomerate. In addition, dripstone fills some cavities.



17. Limestone (wackestone), numerous brachiopods and crinoid stems, beds 1" to 6" thick forming in several places a single ledge, grayish-yellow (5Y 8/4) — 6.5'

16. Limestone (wackestone), massive, numerous irregular joints often with curved fracture surfaces, light gray (N-7); interbedded with highly fossiliferous light gray, thin-bedded wackestone; massive beds generally 1.5' to 4' thick, shaly beds generally less than 2'; brachiopods, horn corals, bryozoans; distinctive inclined joints in upper 10; burrows common — 25'

15. Covered — 5.5'

14. Limestone (mudstone), numerous corals and brachiopods, grayish-yellow (5Y 8/1), top forms upper quarry bench — 3'

13. Limestone (mudstone), burrowed, yellowish-gray (5Y 8/1) with lighter brown mottlings (burrows), scattered brachiopods, upper surface distinct and undulating — 1'

12. Limestone (mudstone), scattered horn corals and brachiopods, light gray (N-7) — 4'

11. Limestone (mudstone), very fine grained, conchoidal fracture, very light gray (N-8) — 5'

10. Limestone (mudstone), very fine grained but slightly coarser than units below, light olive gray (5Y 6/1) — 3'

9. Limestone (mudstone), very fine grained, massive, yellowish-gray (5Y 7/2), lenticular, inset into unit #8 — 0-1.5'

8. Limestone (mudstone), very fine grained, massive except for 0.25' thick stromatolitic bed at base and 0.5' thick stromatolitic bed 2' from top, white (N-9) — 7'

7. Limestone (mudstone), massive, brecciated, conchoidal fracture, light gray (N-7), stromatolites and rip-up clasts in lower 1', breccia up to 0.5' thick in middle and at top — 4'

6. Limestone (mudstone), pale yellowish-brown (10YR 6/2), stromatolites — 5.5'

5. Limestone (mudstone), faintly laminated in lowest 3", pinkish-gray (5YR 8/1), "Milan marker bed" — 1'

4. Limestone (mudstone), solutional contact with unit #3, stromatolites, light olive gray (5Y 6/1) — 5.5'

3. Limestone (mudstone), massive, stromatolites, discontinuous breccia up to 0.5' thick at top, breccia clasts generally less than 1" in diameter, lower bench at top of this unit — 6'

2. Limestone (mudstone), stromatolites, iron sulfides, stylolites, intraclasts, highly brecciated — 7'

1. Limestone (mudstone), iron sulfides, moderate yellowish-brown (10YR 5/4), highly brecciated, base not exposed — 5'

Figure 2. Stratigraphic section of Milan Stone Quarry (modified from Hammer, et al, 1985).

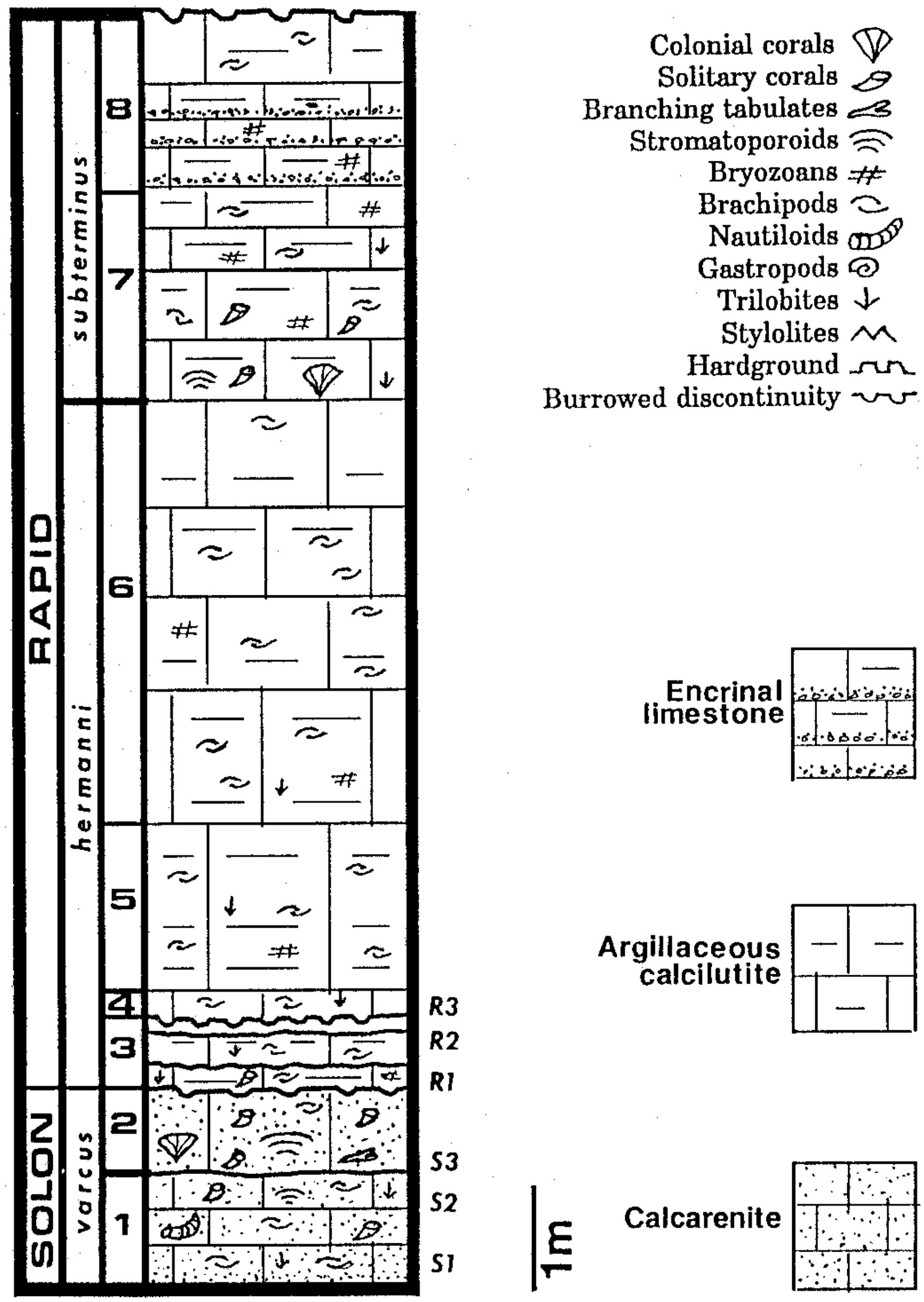


Figure 3. Generalized stratigraphic section of the Little Cedar Formation (Hickerson, 1994) exposed along Mill Creek. Horizons containing articulated trilobites from the Solon Member (S1-S3) and Rapid Member (R1-R3) are indicated.

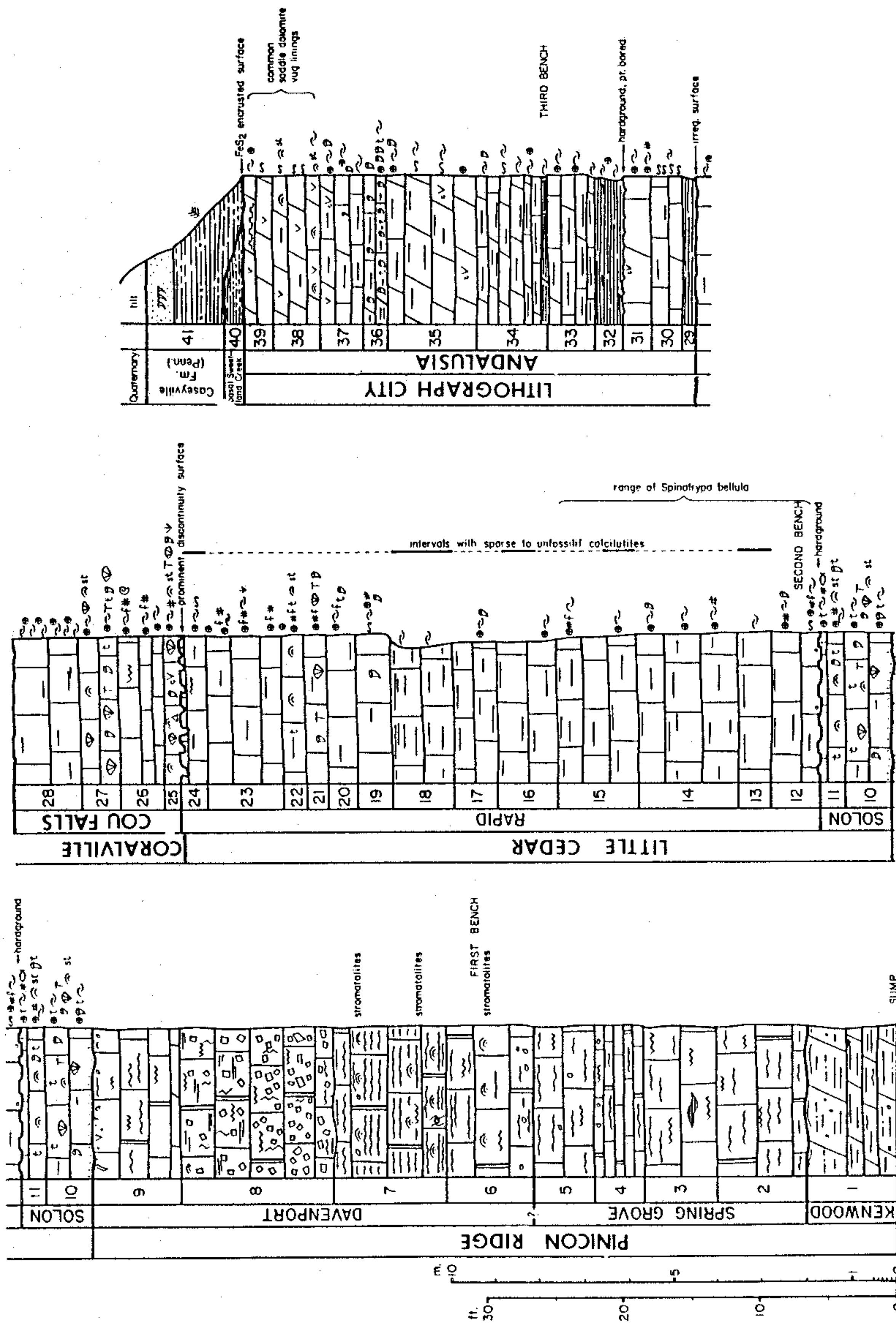


Figure 4. Stratigraphic section of the Davenport Cement Company Quarry (modified from Witzke et al in Hammer, et al, 1985).

STOP 3. Davenport Cement Company Quarry-SW1/4, Sec. 13, T. 77 N., R. 2 E., Buffalo, Scott County, Iowa.

This quarry exposes the most complete section of Devonian strata in the Quad-Cities area. The Pinicon Ridge, Little Cedar, Coralville, Lithograph City, and Sweetland Creek formations are accessible (Fig. 4). The division between the Middle and Upper Devonian lies within the Andalusia Member of the Lithograph City Formation. Pennsylvanian shale and sandstone are exposed at the top of the quarry on the north side.

The upper Rapid (Fig. 4, units 19-23) at this locality has produced many beautifully preserved crinoids and blastoids. Articulated specimens of *Euryocrinus barrisi*, *Eutaxocrinus gracillis*, *Botryocrinus thomasi*, *Decadocrinus* sp., and *Synbathocrinus matutinus*, *Megistocrinus* (2 or 3 sp.), *Nucleocrinus bondi*, *Placoblastus obvatus*, and *Heteroschisma gracillis* have been collected from the west end of the quarry. Trilobite sclerites are common and rare complete specimens (*Phacops norwoodensis*, *Crassiproetus bumastoides*, *C. occidens*, and *Dechenella*? sp.) are associated with the echinoderms. Other fauna from the encrinal beds includes: corals (common *Thamnopora*), brachiopods (Day, *this guidebook*), bryozoans (especially fenestellids), nautiloids (*Acleisotoceras*), and fish fragments (Hickerson, *this guidebook*).

A pyrite encrusted surface occurs at the top of the Lithograph City Formation (Fig. 4, upper part of unit 39) at the top of the north highwall. Large vugs are lined with calcite, selenite, dolomite, pyrite, marcasite, and barite crystals.

The Sweetland Creek Shale is fairly well exposed at the top of the upper bench on the north side of the quarry. Pyrite encrusted internal moulds of brachiopods (*Schizophoria*) and fish debris are present.

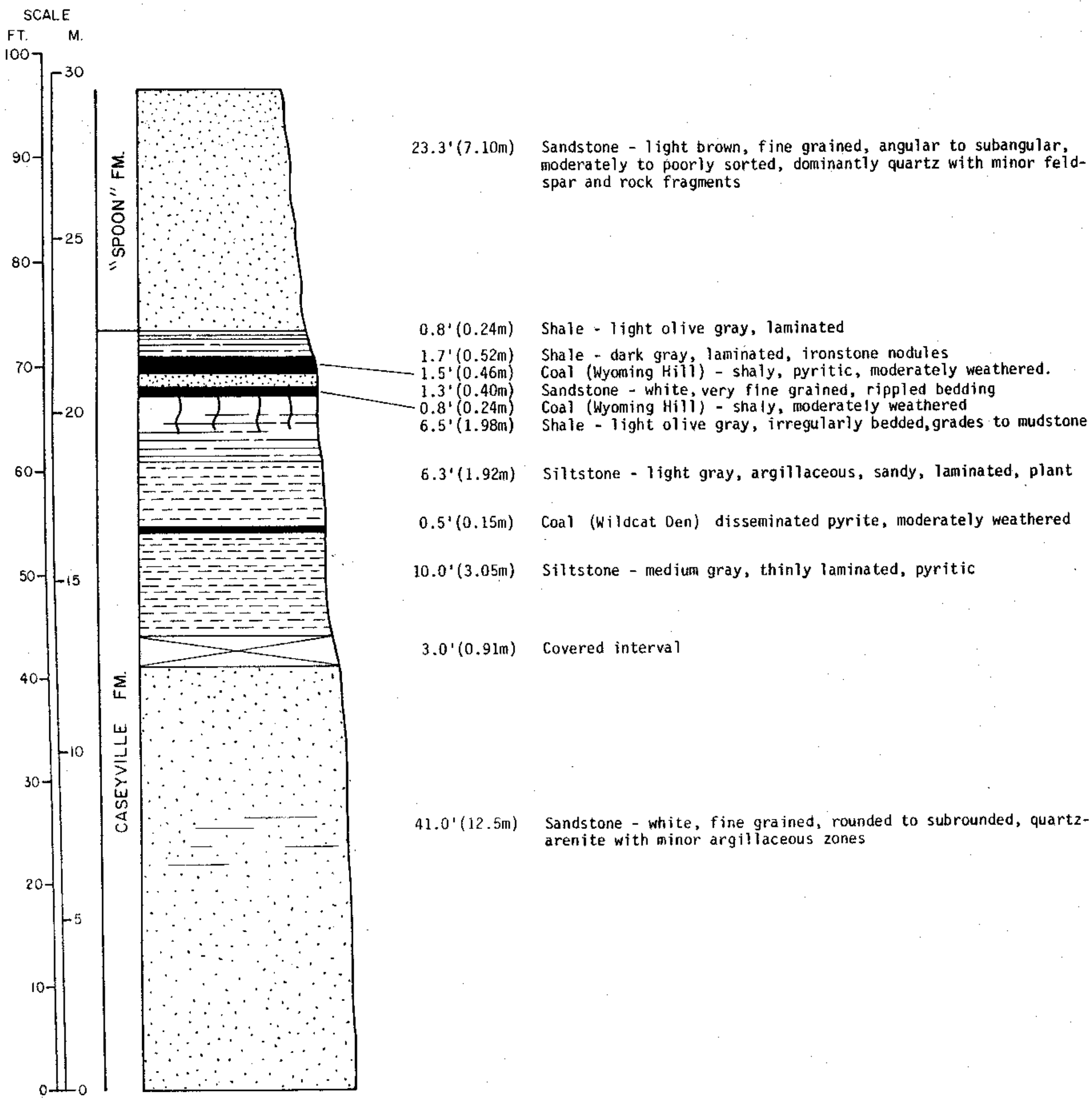


Figure 5. Stratigraphic section at Wyoming Hill along Highway 22, Ne 1/4, sec. 34, T. 77 N., R. 1 W, Muscatine County, Iowa (Ravn, and others, 1984).

STOP 4. Wyoming Hill-NE 1/4, Sec.34 and NW 1/4, Sec. 35, T. 77 N., R. 1 W., Muscatine County, Iowa.

This is a significant site for several reasons: 1) it is the best exposure of Pennsylvanian rocks in the Quad-Cities region, 2) it is the location of a pre-glacial divide between the Ancient Iowa drainage to the west and the Ancient Mississippi drainage to the east, and 3) it is a very unstable slope that poses continual problems of highway and railway maintenance.

Strata below the uppermost massive sandstone are correlated with the Caseyville Formation in Illinois and are the oldest Pennsylvanian rocks in Iowa. The massive sandstone has been tentatively correlated with the Spoon Formation of Illinois on the basis of lithologic similarity, hence it is considered a part of the Cherokee Group of Desmoinesian age (Ravn and others, 1984; Figs. 5 and 6).

The Caseyville Formation at Wyoming Hill probably represents an upper delta plain-alluvial plain complex. Crossbedded sandstones, cut and fill structures, abundant plant fossils, ironstone concretions, several coals, gray to black shales and underclay, and the absence of limestone and marine fossils are the basis for this interpretation. The Spoon Formation may represent superimposed sandstone channels (Ravn, and others, 1984).

Bedrock occurs at higher elevations at Wyoming Hill than it does at any other point along the bluffs of the "upper narrows" of the Mississippi River between Princeton, Iowa, and Muscatine. Hence this site is considered a preglacial divide between the Ancient Iowa River, whose main stem was coincident with the present Mississippi River below Muscatine, and the Ancient Mississippi River that flowed southeastward from the northern end of Rock Island County to the "big bend" of the Illinois River at Hennepin, Illinois (Fig. 7). Ice moving southwestward out of the basin of Lake Michigan blocked the Ancient Mississippi and diverted it across the low point in the divide that is today Wyoming Hill. Temporary diversion probably occurred during Illinoian time, but it was not until Wisconsinan time, perhaps 18,000 years ago, that the present course was firmly established.

Originally this highway was a part of U.S. 61, a major north-south route connecting Duluth, Minnesota, and New Orleans, Louisiana. About 25 years ago, because of recurring slump in the underclay, shales, and siltstones below the Wyoming Hill Coal and because of the expense of maintaining this highway as a major thoroughfare, U.S. 61 between Davenport and Muscatine was relocated about 3 miles to the north, and this highway was renumbered as Iowa Route 22. At the time, the highway at the crest of the hill lay at about the level of the base of the upper massive sandstone, and the problems with slump occurred on the cut below the highway. In the mid 1980s the grade of the highway was lowered about 20 feet. This put the highway on the lower, more stable, fine-grained sandstone at the base of the cut. This did not completely solve the problem, however, because now the shales are above the highway, and they now slump down onto the highway carrying large blocks of the Spoon Formation with them.

Stratigraphic Nomenclature - This Report				
Western Interior Basin			Eastern Interior Basin, Scott & Muscatine Counties	
GROUP	FORMATION	Named Member	FORMATION	Named Member
MARMATON	"LOST BRANCH"	Cooper Creek Ls. unnamed Sh. Sni Mills Ls.		
	UNNAMED SH.			
	LENAPAH LS.			
	NOWATA SH.			
	ALTAMONT	Worland Ls. Lake Neosho Sh. Amoret Ls.		
	BANDERA SH.			
	PAWNEE	Coal City Ls. Mine Creek Sh. Myrick Sta. Ls. Anna Sh.		
	LABETTE SH.	Mystic Coal Marshall Coal		
	STEPHENS FOREST	Higginsville Ls. unnamed sh. Houx Ls. Little Osage Sh.		
	MORGAN SCHOOL SH	Summit Coal		
	MOUSE CREEK	Blackjack Creek Ls. Excello Sh.		
CHEROKEE	SWEDE HOLLOW	Mulky Coal Bevier Coal Wheeler Coal Ardmore Ls. Oakley Sh. Whitebreast Coal		
	FLORIS	Carruthers Coal unnamed coal Laddsdale	? "SPOON" ?	
	KALO	Cliffland Coal Blackoak Coal		
	KILBOURN	unnamed coals		
			CASEYVILLE	Wyoming Hill Coal Wildcat Den Coal

Figure 6. Morrowan and Desmoinesian stratigraphy of Iowa (Ravn, and others, 1984).

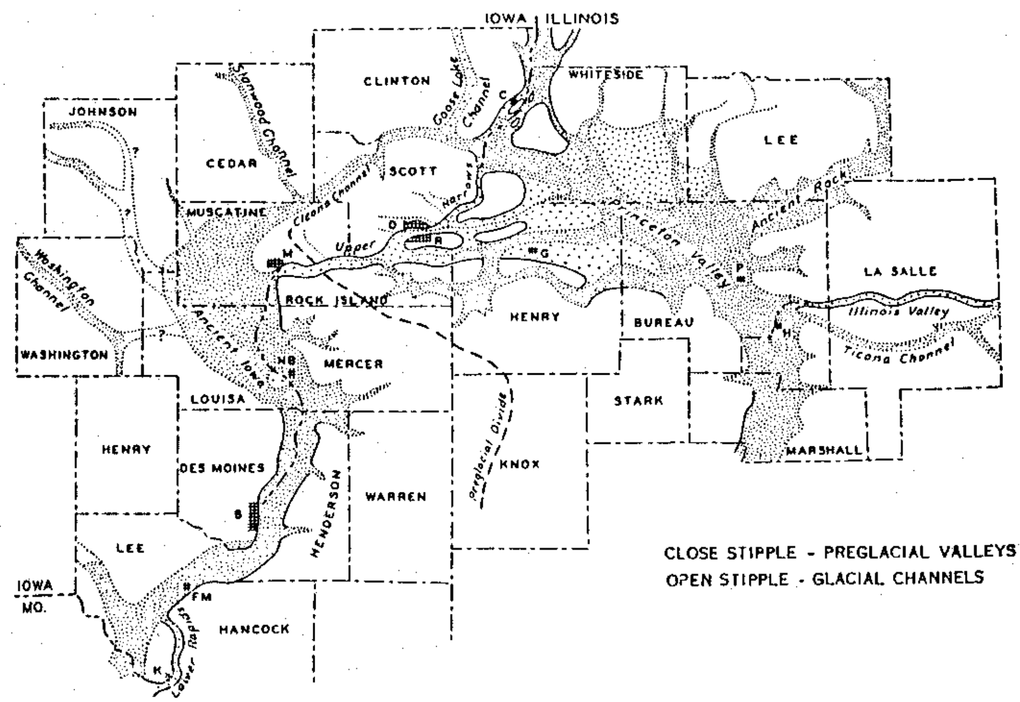


Figure 7. Bedrock channels in the Rock Island region, northwestern Illinois and eastern Iowa. B-Burlington; C-Clinton; D-Davenport; FM-Fort Madison; G-Geneseo; H-Hennepin; K-Keokuk; M-Muscatine; NB-New Boston; P-Princeton; R-Rock Island. Channels in Iowa compiled from data by Udden, Norton, Clavin, Leighton, and Schoewe. (Horberg, 1950).

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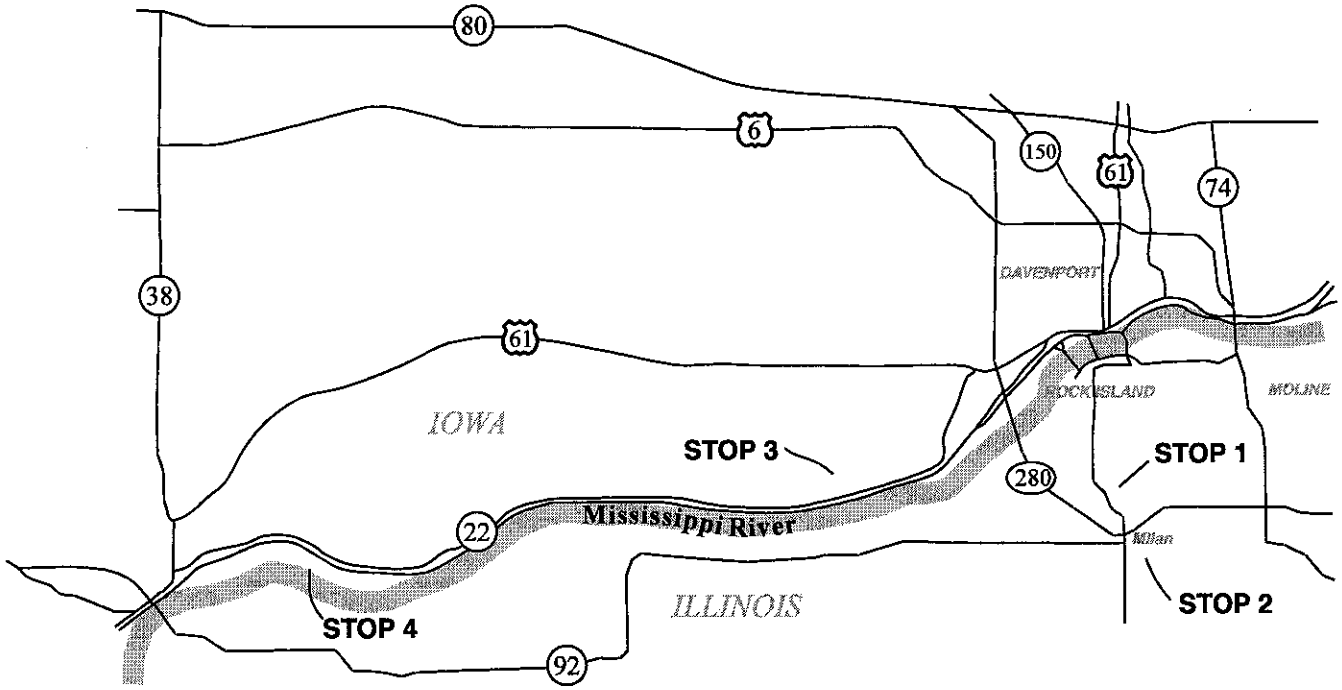
Geological Society of Iowa
109 Trowbridge Hall
Iowa City, Iowa 52242-1319



LOCATION MAP OF FIELD TRIP STOPS