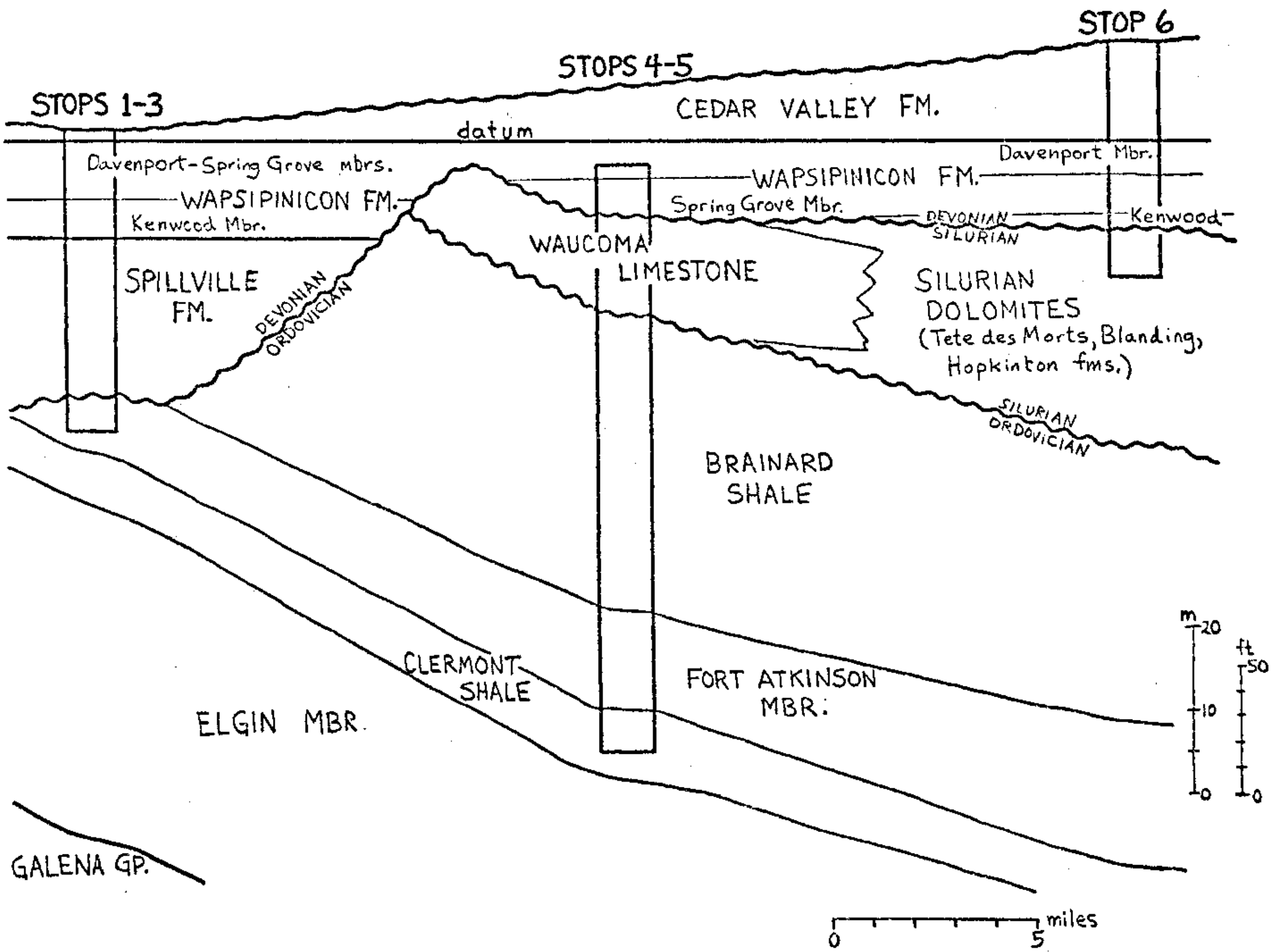
NEW STRATIGRAPHIC INTERPRETATIONS OF THE MIDDLE DEVONIAN ROCKS OF WINNESHIEK AND FAYETTE COUNTIES, NORTHEASTERN IOWA



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Geological Society of Iowa
Field Trip Guidebook No. 39
April 24, 1983

NEW STRATIGRAPHIC INTERPRETATIONS OF THE MIDDLE DEVONIAN ROCKS OF WINNESHIEK AND FAYETTE COUNTIES, NORTHEASTERN IOWA

INTRODUCTION

Since the last Geological Society of Iowa field trip (Koch and Michael, 1965) passed through the Howard, Winneshiek, and Fayette Counties area, new litho- (Bunker *et al.*, 1983) and biostratigraphic (Klapper and Barrick, 1983) interpretations of the Middle Devonian rocks in the area have emerged. The purpose of this report is to review the lithostratigraphic relationships of the Middle Devonian rocks in northeastern Iowa, relate them to the known stratigraphic sequences in east-central Iowa, and emphasize the effect of paleotopographic relief on the pre-Middle Devonian unconformity on pre-Cedar Valley sedimentation (Spillville and Wapsipinicon Formations).

A summary of the present understanding of the stratigraphic relationships in Howard, Winneshiek, and Fayette Counties, and the lithostratigraphy follows.

PREVIOUS INTERPRETATIONS

Stratigraphic correlations of Middle and Upper Devonian rocks in the central midcontinent region have been a subject of controversy among regional geologists for years. The Independence Shale, for example, is a famous stratigraphic problem in eastern Iowa which influenced the age placement of the Cedar Valley Limestone. Paleontologic evidence now indicates that the Independence Shale represents a stratigraphic leak of Upper Devonian shales and possible Upper Mississippian (Chesterian) continental sediments into karstified Cedar Valley, Wapsipinicon, and Silurian carbonates. Likewise, differing stratigraphic correlations of Devonian rocks in western Winneshiek and eastern Howard Counties have been proposed. Some geologists placed these rocks entirely within the Cedar Valley Limestone, whereas others correlated part of the sequence to the Wapsipinicon Formation.

Early stratigraphic interpretations of the Devonian rocks in Howard and Winneshiek Counties suggested to Calvin (1903, 1906) that these rocks were not the same as the lowest Devonian rocks present in east-central Iowa. The presence of fossiliferous carbonates, in particular beds containing *Productella subalata* Hall and "*Spirifer*" *pennatus* Owen, suggested to Calvin that these beds may correlate to the upper portion of the Wapsipinicon Formation as defined at that time (Norton, 1895). Calvin (1903, p. 50), however, did note an anomaly in the biostratigraphic distribution of certain fauna in these beds. He stated:

> ". . . For example the Productella beds have a thickness of forty feet, a thickness more than twice as great as that of the corresponding beds at Independence. They are overlain by fifteen to twenty feet of coarse dolomite characterized by the inclusion of

large masses of crystalline calcite. In these coarse, calcite bearing beds there are occasional casts and impressions of *Favosites alpenensis* and *Acervularia davidsoni*. These corals are in their usual stratigraphic relation to Productella and so far the succession of life zones is in accord with the Devonian section in Buchanan County. But in the Salisbury quarry at Vernon Springs, twenty feet or more above the top of the coarse, coral bearing dolomite, there are layers only slightly magnesium in which *Gypidula comis*, *Atrypa aspera*, and the lenticular elongated, finely striated type of *Atrypa reticularis*, known heretofore only from the horizon of the Independence quarries are well preserved. This particular form of the *Atrypa reticularis* should be found below the coral horizon and never above. Its place is with the Productella. . . "

This repetition of biostratigraphic zones has apparently not been recognized by later workers in the area. Stauffer (1922, p. 406), however, referred to brecciated limestones (possibly the Davenport Member of the Wapsipinicon Formation) occurring in the Minnesota Devonian. Stauffer thought these brecciated beds probably represented "important breaks in sedimentation, during which marked faunal changes occurred." Later investigations of the Minnesota Devonian (Kohls, 1961; Mossler, 1978) apparently did not recognize this relationship.

In 1935, M. A. Stainbrook reclassified the Cedar Valley Limestone and the Wapsipinicon Formation, proposing new member subdivisions for both. Stainbrook's (1935) conception of the stratigraphic framework of the Middle Devonian rocks from east-central Iowa north to Howard and Winneshiek Counties is illustrated in figure 1. Stainbrook believed that the Independence Shale was in true stratigraphic position, lying between the Cedar Valley and the Wapsipinicon, and that the Cedar Valley overlapped the Wapsipinicon to the north, as originally suggested by Calvin (1903, 1906).

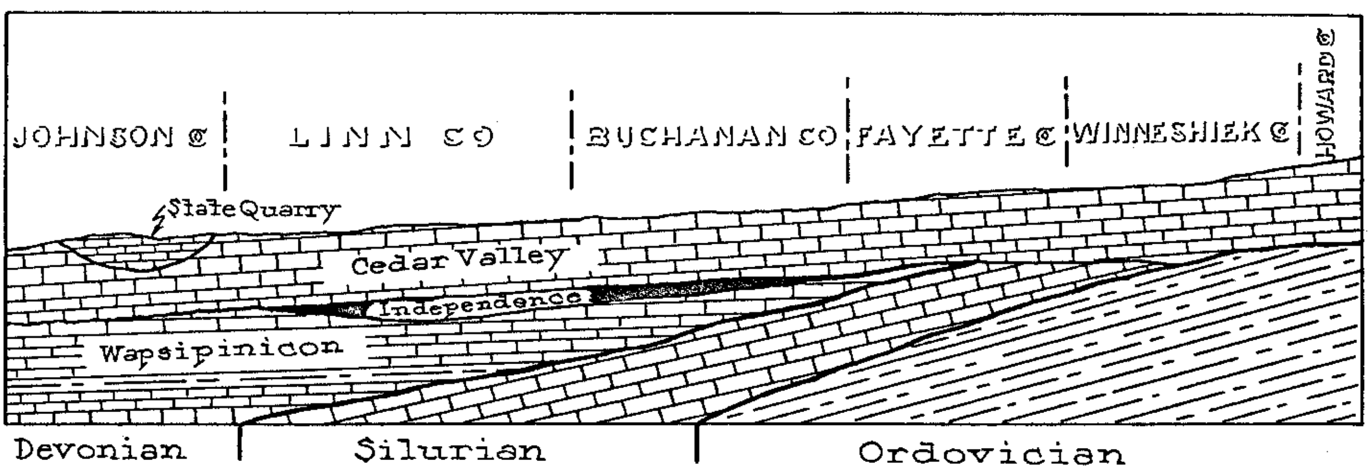


Figure 1. Generalized cross-section from Stainbrook (1935, p. 258), which illustrates his conceptions of the stratigraphic relationships of the Middle Devonian rocks across eastern Iowa. These ideas were prevalent during the first 75 years of the 20th century.

In 1965, Koch and Michael discussed the lithologic relationships of the Devonian rocks in Howard and Winneshiek Counties. They noted that the lowest Devonian rock units in eastern Howard County were overlain by a sequence of rocks that "contains a breccia at the top, a platy unit in the middle, and a dolomitic shale or siltstone at the base." They questioned whether this interval could represent the lower Rapid or whether it correlated with the Wapsipinicon. Calvin (1903, p. 51; 1906, p. 113-115) identified the occurrence of "*Spirifer subumbona*" (i.e. *Emanuella*) in the lowest beds in Howard and Winneshiek Counties, and the same brachiopod species was also noted by Norton (1895, 1920) in the Otis of east-central Iowa. Koch and Michael (1965, p. 14) suggested the possible equivalency of the lowest beds in Howard and Winneshiek Counties with the Otis, based upon the presence of this fossil. However, Dorheim and Koch (1966) later referred these rocks back to the Cedar Valley, assigning them to the Solon, and the overlying sequence of rocks were referred to the lower Rapid. Bunker *et al.* (1983) recognized the lithostratigraphic relationships of the Cedar Valley, Wapsipinicon, and an "unnamed Otis equivalent." Klapper and Barrick (1983) formally defined the "unnamed Otis equivalent" as the Spillville Formation.

MIDDLE DEVONIAN LITHOSTRATIGRAPHY

Spillville Formation (new, Middle Devonian)

The Spillville Formation consists of a medium- to extremely fine-grained, calcitic dolostone. It is fossiliferous, including brachiopods (*Atrypa*, *Productella*, and "*spiriferids*" are common), solitary and colonial corals, trilobites, pelmatozoans, gastropods, and tentaculitids (Dorheim and Koch, 1966). In north-central and northeast Iowa the Spillville unconformably overlies the Upper Ordovician Maquoketa Formation. It varies in thickness from 0 to 75 feet (23 m), thinning towards the south. Klapper and Barrick (1983) formally defined the Spillville Formation and designated the Spillville Quarry (SE NE SE section 20, T97N, R9W) as the type section.

A clastic interval which has not been previously recognized occurs persistently at the base of the Spillville across northern Iowa. This basal Devonian clastic sequence was formerly placed in the Upper Ordovician by earlier workers who had assigned it to different members of the Maquoketa Formation. This basal clastic interval is composed of silty to sandy mudstone, and argillaceous siltstone and very fine grained sandstone. It is dolomitic to calcareous to varying degrees across the area. Angular clasts of chert from the underlying Ft. Atkinson Member of the Maquoketa Formation are found locally within this clastic interval. This unit is informally referred to as the "Lake Meyer member" of the Spillville Formation. The primary reference section (Stop 3) is located at the north end of the dam at Lake Meyer County Park (SW SW SW NE section 33, T97N, R9W), approximately two miles south of the Spillville type section. The "Lake Meyer member" varies in thickness from 0 to 15 feet (4.6 m) across northern Iowa.

Wapsipinicon Formation

The Wapsipinicon Formation was named (Norton, 1895) for exposures along the Wapsipinicon River in northeastern Linn County, Iowa. It has long been recognized as one of the most enigmatic rock units of the Iowa stratigraphic column. The stratigraphic position of the Wapsipinicon Formation and its contained members has been confused in the past because of the poorly to unfossiliferous nature of the section, vertically repetitive lithologies, extensive brecciation, and the regionally persistent occurrence of Upper Devonian stratigraphic leaks within and adjacent to the unit.

Four members of the Wapsipinicon Formation are presently recognized (Bunker *et al.*, 1983), which in ascending order are: the Otis, Kenwood, Spring Grove, and Davenport. In northeastern Iowa, only the Kenwood, Spring Grove, and Davenport Members are recognized.

Kenwood Member

The Kenwood is the most lithologically variable member of the Wapsipinicon Formation. It consists of bluish-gray to grayish-brown, sandy, silty, argillaceous, unfossiliferous, ferroan limestones and dolomites with interbedded sandy to silty shales. In northeastern Iowa, the Kenwood ranges in thickness from 0 to 15 feet (4.6 m) and disconformably overlies the Spillville Formation (Middle Devonian) and the Silurian limestones (Waucoma Limestone) and dolomites.

Spring Grove Member

In east-central Iowa, the Spring Grove is predominantly a porous, well laminated, nonferroan, fine to medium crystalline dolomite, that is in part brecciated. It typically emits a mild to strong petroliferous odor when crushed and ranges in thickness from 20 to 25 feet (6.1-7.6 m).

In northeastern Iowa, the characteristic laminations and petroliferous odor are still prevalent, but the Spring Grove is a dolomitic limestone or limestone in this area rather than dolomite as is typical in east-central Iowa. It may be locally brecciated and indistinguishable from the overlying Davenport, except where the Davenport is a well-developed breccia and the Spring Grove is well bedded.

The Spring Grove overlaps the Kenwood from the north and south and lies disconformably upon the Waucoma Limestone (Silurian) in northern Fayette County. Where the Spring Grove directly overlies the Silurian, Pearson (1982) noted fine to medium sand and silt grains as well as some reworked silicified echinoderm debris from the underlying Waucoma Limestone. Stromatolites can be observed near the top of the Spring Grove at Goeken Park in north-central Fayette County.

Davenport Member

The Davenport is a light gray to dark brown sublithographic to lithographic limestone. It is unfossiliferous, although algal-stromatolites have been reported in the Cedar County, Iowa and Rock Island, Illinois areas (Don Koch, IGS, pers. comm.). The Davenport is commonly thin- to medium-bedded, stylolitic, and usually is highly brecciated. The breccias are composed of angular chips and blocks of lithographic limestone in a matrix of sandy, argillaceous limestone or dolomite. In his treatise on the "Wapsipinicon Breccias of Iowa," Norton (1920) provided detailed descriptions of these breccias. The origin of the brecciation in the Wapsipinicon has long been a controversial subject. The presence of gypsum-anhydrite evaporites in the Wapsipinicon Formation, known from the subsurface of central and southeastern Iowa (Dorheim and Campbell, 1958; Church, 1967; Sendlein, 1964, 1968, 1972) strongly suggests that evaporite solution-collapse may be responsible for the bulk of the widespread brecciation. However, the variety of types of brecciation described by Norton (1920) may not be attributable to a single causative agent.

The Davenport is disconformably overlain by the Solon Member of the Cedar Valley Limestone. The contact is difficult to pick with any degree of consistency where the Davenport is brecciated because of stratigraphic leakage of Solon materials downward into the brecciated interval. Davenport breccia fragments and/or blocks are surrounded by a matrix of basal Solon sand (Hoing Sandstone) and/or carbonate mud, intraclasts, and fossils. The contact, however, is usually picked at the highest occurrence of Davenport clasts within the brecciated interval.

The Davenport overlaps the Spring Grove from the north and south in extreme northern Fayette County, and can be locally found disconformably overlying the Waucoma Limestone (Silurian). The Davenport varies from a few feet to about 16 feet (5 m) in thickness across north-central Iowa.

Cedar Valley Limestone

The present member subdivisions of the Cedar Valley Limestone (Keyes, 1912) are defined in terms of faunal zones established by Stainbrook (1941). These members are in ascending order--the Solon, Rapid, Coralville--all named for exposures near Iowa City, Johnson County, Iowa. Lithostratigraphic investigations in east-central Iowa by Kettenbrink (1973) verified essentially the same member boundaries established by Stainbrook (1941).

The litho- and biostratigraphic relationships of the Cedar Valley Limestone in Howard, Winneshiek, and Fayette Counties are poorly defined. Age equivalent rocks of the Solon Member are noted in the Howard County area (Klapper and Barrick, 1983), in the Winneshiek County area (Stop 2), and in the Fayette County area (Stop 6). Unfortunately, their lithostratigraphic relationships to the type Solon in east-central Iowa area have never been investigated. Studies are currently being initiated and the results will be reported in the future.

MIDDLE DEVONIAN BIOSTRATIGRAPHY

The standard conodont zonation of the Middle Devonian is that developed primarily on the basis of sequences in central Europe (Weddige, 1977; Klapper and Ziegler, 1979), but it is applicable in western North America (e.g. Nevada, Yukon) as well as New York. A part of the standard zonation is shown in the left-hand column of figure 2. Not shown are the *partitus*, *costatus costatus*, and *australis* Zones below the *kockelianus* Zone and the Upper *Hermanni-cristatus* Subzone, *disparilis* and Lowermost *asymmetricus* Zones at the top of the Middle Devonian. The Eifelian-Givetian stage boundary is within the *ensensis* Zone and the lower boundary of the Upper Devonian is now defined by the Devonian Subcommission to coincide with the base of the Lower *asymmetricus* Zone (reviewed in Ziegler and Klapper, 1982).

The standard zonation is defined and applies to sequences characterized by relatively off-shore conodont biofacies. Other well-known conodont sequences such as those in the Northwest Territories, Canada (Chatterton, 1979; Uyeno, 1979), in Manitoba (Norris *et al.*, 1982), and in the Michigan Basin (Orr, 1971) are characterized by near-shore conodont biofacies in the Eifelian and lower Givetian parts of the Middle Devonian. Generally not until the level of the Middle *varcus* Subzone do these sequences have species of the off-shore biofacies, which are the diagnostic zonal indicators.

The Spillville Formation in Howard and Winneshiek Counties, northern Iowa, and in Mower and Fillmore Counties, southern Minnesota (Klapper and Barrick, 1983) contains the following conodont fauna in its lower part: *Icriodus calvini*, *I. orri*, *Ozarkodina raaschi*, *Polygnathus curtigladius*, *P. intermedius*, *P. para-webbi*, and *P. linguiformis linguiformis* gamma, among others. The lower Spillville fauna correlates with similar faunas containing *Polygnathus curtigladius* in the lower Elm Point Formation in southern Manitoba (Norris *et al.*, 1982) and in the upper Hume Formation in the MacKenzie Mountains, Northwest Territories (Chatterton, 1979; Uyeno, 1979); i.e. the *curtigladius* Fauna. Correlation of the *curtigladius* Fauna with the standard zonation is problematic (Klapper and Ziegler, 1979, p. 207), but it is presumed to correlate approximately with the *kockelianus* Zone of the late Eifelian (fig. 2).

In common with the lower part of the Spillville Formation, the type Lake Church Formation near Milwaukee, Wisconsin (Schumacher, 1971, loc. 1; Schumacher's samples are from the upper part of the Ozaukee Member according to G. O. Raasch, 1980, written comm.) has *Icriodus orri*, *Polygnathus parawebbi*, and *P. linguiformis linguiformis* gamma morphotype. The Lake Church additionally has *Polygnathus angustipennatus*, a species which ranges in Europe from the *australis* Zone into the lowest part of the *ensensis* Zone, Eifelian (Weddige, 1977, tables 2, 5; Klapper and Johnson, 1980, tables 8, 9). Of the three listed above as common to the lower Spillville and Lake Church, however, *Icriodus orri* is the only short-ranging species. Its occurrence supports the megafaunal correlation made many years ago by Raasch (1935, p. 263), who indicated that the fauna and lithology of the Belgium (lower) Member of the Lake Church Formation "is duplicated in the basal Devonian at Spring Valley, Minnesota." These strata are part of the Spillville Formation. Cooper *et al.* (1942, p. 1770 and chart no. 4), who quoted Raasch's correlation, showed a

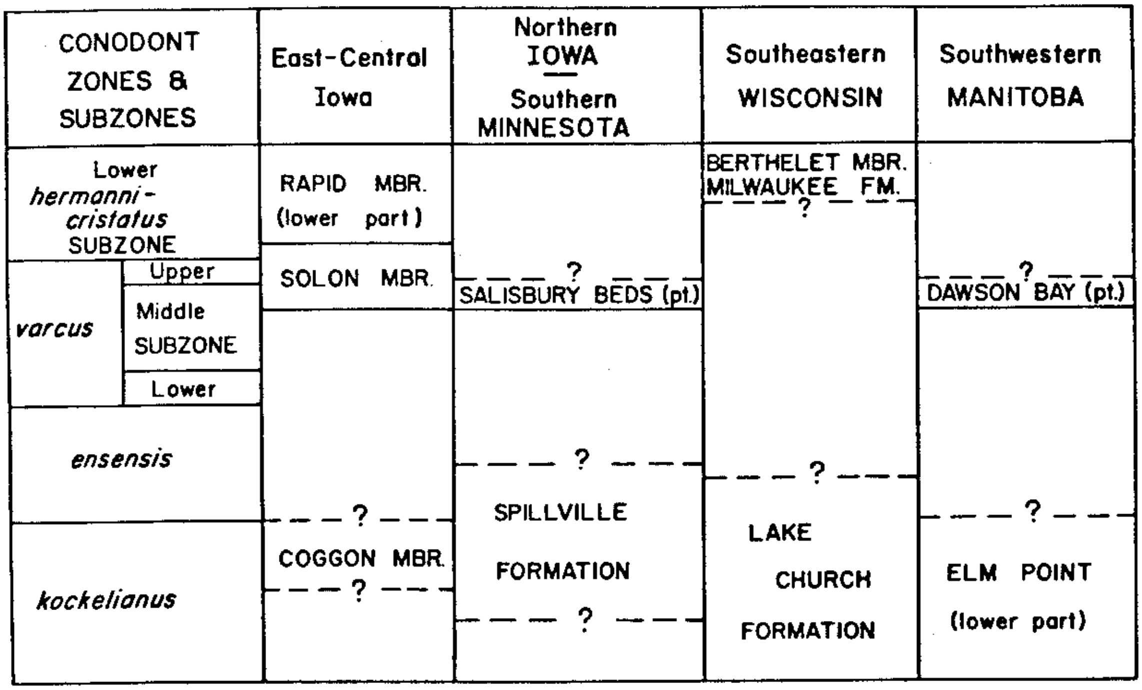


Figure 2. Biostratigraphic correlation diagram of Spillville Formation and suggested equivalents elsewhere in Iowa, Wisconsin, and Manitoba (from Klapper and Barrick, 1983). Part of the standard conodont zonation is shown in the left-hand column and is briefly discussed in the text. Rock units that have not as yet yielded diagnostic conodont faunas are not shown on this diagram.

unit termed "'Cedar Valley' limestone (part)" opposite the Lake Church of Wisconsin and separated by a substantial hiatus from a higher part of the Minnesota "Cedar Valley." The latter was shown in correlation with the Cedar Valley of Iowa.

A level with the brachiopod *Emanuella* and fragmentary trilobites near the base of the Coggon Member of the Wapsipinicon Formation (note that Bunker *et al.*, 1983, treat the Coggon as a facies of the Otis Member) at the Bealer quarry, in Cedar County, southeastern Iowa, yields a well-preserved but impoverished conodont fauna consisting of only one species, *Ozarkodina raaschi*. Although this is admittedly sparse evidence, as a hypothesis it is suggested that the *Emanuella* level at the Bealer quarry correlates with some part of the Spillville Formation (fig. 2).

The upper part of the Spillville Formation, that is the part at and above the first appearance of *Ozarkodina brevis*, presumably correlates with a higher position than that suggested for the lower part. *Ozarkodina raaschi*, which occurs in the lower Spillville below the lowest *O. brevis*, and ranges up into the beds with it, is known in central Nevada in the *costatus costatus* and *kockelianus* Zones (Klapper and Johnson, 1980, tables 7, 8). *O. brevis* ranges in Nevada from the *ensensis* Zone through the *dengleri* Zone (same reference, tables 9-12). Thus, the upper Spillville with *O. raaschi* and *O. brevis* in association may be correlated with a position no lower than the *ensensis* Zone (fig. 2). The upper Spillville also has *Polygnathus parawebbi* and *Icriodus orri*, suggestive evidence that the strata correlate no higher than the *ensensis* Zone.

Strata between the Spillville Formation and the Cedar Valley Formation in northern Iowa have not yet yielded conodonts. Basal beds of the Cedar Valley (the so-called Salisbury beds on fig. 2), however, in the Salisbury quarry at Vernon Springs (SW SW sec. 34, T99N, R11W, Howard County) and at Stop 2, have a fauna including *Polygnathus ansatus* and other species of the Middle *varcus* Subzone, within the Givetian. Faunas of the Middle *varcus* Subzone have been identified in the basal Solon Member of the Cedar Valley at three localities in Fayette County (including Stop 6), at the Brooks quarry in Independence, Buchanan County, and at the type Solon section in Johnson County (Klapper and Barrick, 1983). Thus, there is a clear difference between the conodont faunas of the Spillville and the basal Cedar Valley Formations.

SILURIAN LITHOSTRATIGRAPHY

Devonian rocks overlie Siurian strata over much of Iowa, and we will examine exposures in northeast Iowa where the Wapsipinicon-Silurian contact can be seen. Proceeding north from east-central to northeast Iowa the Silurian sequence is progressively truncated beneath the Devonian. Over most of eastern Iowa, Silurian carbonate rocks are entirely dolomitized, but Silurian limestones are noted in northern Fayette County and parts of adjacent counties. The Silurian dolomite sequence is laterally replaced by a limestone facies in the West Union area. The Silurian dolomite interval in central and southern Fayette County is subdivided into the standard Iowa Lower Silurian formational sequence. In ascending order, the following formations are recognized: 1) Mosalem Formation; locally developed within lows on the Maquoketa erosional surface; primarily thinly-bedded argillaceous dolomite. 2) Tete des Morts Formation; a thick-bedded dolomite with a conspicuous coral-stromatoporoid fauna; directly overlies the Maquoketa at some localities; about 5 m thick. 3) Blanding Formation; a very cherty dolomite interval with a coral-stromatoporoid fauna; 7 to 12 m thick. 4) Hopkinton Formation; a dolomite and cherty dolomite interval; the Hopkinton is erosionally beveled beneath the Devonian in Fayette County and is correspondingly thinned; less than 15 m thick. A Silurian limestone unit was first identified in Fayette County by Savage (1905), who later named this interval the Waucoma Limestone after exposures near the village of Waucoma (Savage, 1914). Savage (1926) subsequently dropped the term Waucoma and replaced it with the term "Kankakee limestone" because of supposed correlation between northeast Iowa and the type Kankakee in northeast Illinois. Scobey (1935) disagreed with Savage's correlation and re-assigned the limestones at Waucoma to the "Edgewood," a unit first named in Missouri. Johnson (1977) and Witzke (1981) concluded that the Edgewood and Kankakee were mistakenly correlated into the Iowa sequence and that, as originally defined, these units cannot be recognized in the state. Therefore, Witzke (1981) suggested that the Waucoma Limestone Formation should be resurrected as a term for the Silurian limestone sequence of Fayette County and adjacent areas of Bremer, Chickasaw, and Winneshiek Counties.

The Waucoma limestones are generally extremely pure, although some dolomite and argillaceous to sandy beds occur. Some cherty limestones are also noted. The limestones typically have crinoidal wackestone to packstone textures, and corals and stromatoporoids are locally prominent. In parts of Fayette County the Waucoma Limestone is overlain by Hopkinton dolomites, although the Wapsipinicon Formation directly overlies the Waucoma Limestone at most localities.

The Waucoma ranges from 0 to 20 m in thickness in Fayette County. Correlation of the Waucoma Limestone with the standard Iowa dolomite units to the south is not yet clarified. Witzke (1981) tentatively correlated the Waucoma Limestone with the Tete des Morts, Blanding, and lower Hopkinton intervals in the dolomite sequence to the south. Where the Waucoma is thin, it probably correlates only to the Tete des Morts and Blanding Formations.

UPPER ORDOVICIAN LITHOSTRATIGRAPHY

Basal Devonian strata overlie various members of the Upper Ordovician Maquoketa Formation in portions of northeast Iowa and southeast Minnesota. The classic sequence of members within the Maquoketa Formation was named for exposures in the Fayette-Winneshiek County area. In the vicinity of the Fayette-Winneshiek County line, Devonian strata rest on the Brainard Shale Member, the upper member of the Maquoketa Formation. The Brainard Shale forms a prominent shale slope beneath the Silurian Escarpment in northeast Iowa. The Brainard, where covered by the Silurian, reaches thicknesses up to 40 m. It is primarily a gray-green dolomitic shale, and dolomite interbeds occur within the sequence, especially in the upper 5 to 10 m. The Brainard contains few macrofossils throughout most of the sequence, although the upper interval has produced an abundant invertebrate fauna from the carbonate interbeds ("Cornulites Zone" of Ladd, 1929).

In the vicinity of Spillville, Fort Atkinson, and Calmar, Devonian strata rest on the Fort Atkinson Member of the Maquoketa Formation, where the entire Brainard sequence was removed prior to the onset of Devonian sedimentation. However, the Brainard Shale overlies the Fort Atkinson over most of northeast Iowa. The Fort Atkinson is a cherty carbonate interval, and a great variety of well-preserved invertebrate fossils have been collected from the unit. Proceeding southward along the Maquoketa outcrop belt of northeastern Iowa, the Fort Atkinson disappears and is replaced by gray-green shales indistinguishable from the Brainard. The Fort Atkinson is absent at the type locality of the Maquoketa Formation in Dubuque County and over much of east-central Iowa. The Fort Atkinson of eastern Iowa ranges from 0 to 20 m in thickness.

The Clermont Shale Member underlies the Fort Atkinson in northeast Iowa, where it generally ranges from 3 to 8 m in thickness. The Clermont is a gray-green to gray dolomitic shale with argillaceous carbonate interbeds. It is, in part, a fossiliferous unit, and a variety of brachiopods and other fossils are noted. A sandy carbonate unit present beneath the Spillville Formation in southeast Minnesota was tentatively assigned to the Clermont Member by Bayer (1967), although this unit lacks shale beds characteristic of the Clermont in Iowa.

The basal interval of the Maquoketa Formation in Iowa and Minnesota is assigned to the Elgin Member. The Elgin reaches thicknesses of 35 m in the Fayette County area (Parker *et al.*, 1959), but the Elgin thins northward into Minnesota. The Spillville Formation directly overlies the Elgin over most of southeastern Minnesota (Kohls, 1961) and large areas of Howard and Mitchell Counties, Iowa. The Elgin Member in northeast Iowa is primarily a shaly carbonate unit, in part cherty, with a conspicuous trilobite fauna. The Elgin in Minnesota is also primarily a cherty carbonate, but the unit there is siltier and contains diverse benthic fossil associations (Bayer, 1967). Southward in the outcrop belt of eastern Iowa, the Elgin carbonates are replaced by brown shales with phosphorite and dolomite interbeds. This brown shale unit is included in the Scales Shale of Illinois.

TECTONIC AND DEPOSITIONAL HISTORY

The Upper Mississippi River Valley is located in the central stable interior region of the North American continent, an area that has not experienced orogenic activity since the Proterozoic. Late Proterozoic, Paleozoic, and Mesozoic sedimentary rocks in this region rest unconformably on a cratonic basement of igneous and metamorphic Precambrian rocks. The Phanerozoic non-marine to shallow marine sedimentary package was deposited intermittently on the craton in a series of six major transgressive-regressive cycles of deposition (fig. 3; Sloss, 1963), each of which are separated by a continental-wide unconformity.

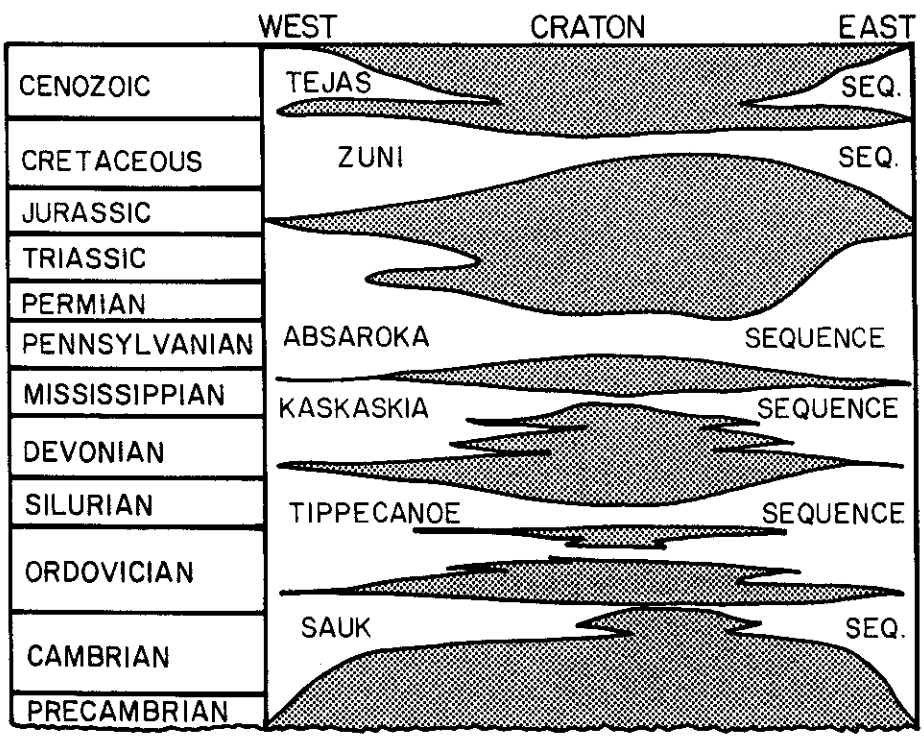


Figure 3. Time-stratigraphic relationships of the cratonic sequences on the North American continent. Shaded areas represent the major unconformities recorded in the rock record across the continent. The more complete depositional sequences are preserved at the continental margins (modified from Sloss, 1963, p. 110).

The Kaskaskia Sequence in the central midcontinent region consists of strata that rest upon the interregional unconformity developed on Tippecanoe and older rocks (fig. 4) and underlie an interregional unconformity at the base of the overlying Absaroka Sequence. Sloss (1963) defined the age of the Kaskaskia Sequence as ranging from late Early Devonian to latest Mississippian (Chesterian). Early Devonian rocks are not present in Iowa, and Chesterian(?) continental sediments are present only as stratigraphic leaks into the older Kaskaskia rocks (Bunker *et al.*, 1983).

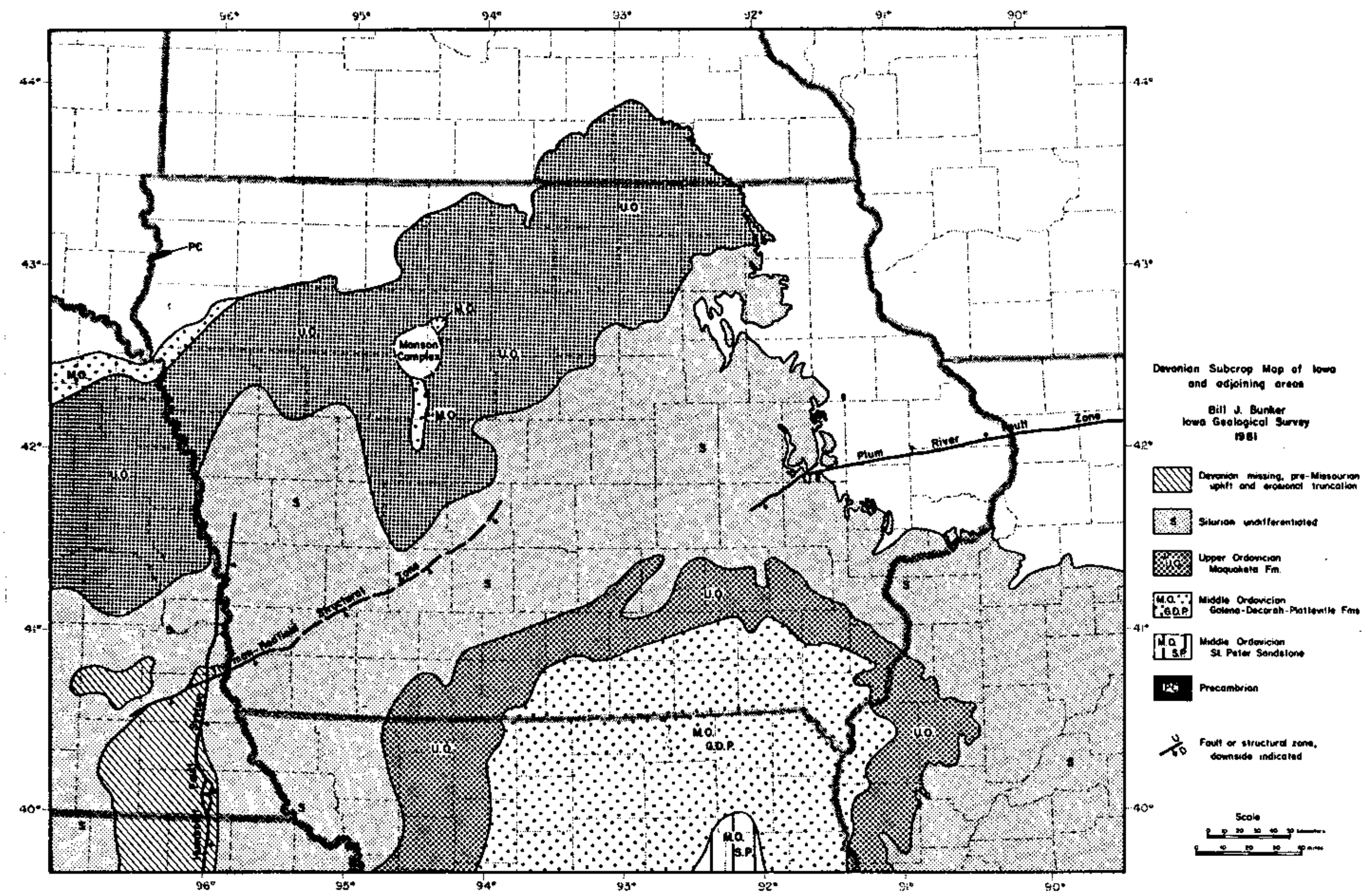


Figure 4. Paleogeologic map of the pre-Kaskaskia surface in Iowa and adjoining states (from Bunker *et al.*, 1983).

Prior to the basal Kaskaskia (Middle Devonian) transgression into the central midcontinent region, an extensive period of erosion (approximately 40 million years) ensued, during which several hundred feet of Lower Devonian through Upper Cambrian rocks were stripped from the North American craton. The younger sediments of the Tippecanoe sequence (fig. 3) were preserved in areas of greater structural subsidence. Figure 4 is a subcrop map showing the distribution of Tippecanoe and earlier rocks which underlie the Kaskaskia Sequence in Iowa. Silurian strata were preserved in a north-northeast to south-southwest trending trough-like depression across the central part of Iowa. This depressed area has been subdivided (Bunker *et al.*, 1983) into two structural/depositional basins: the North Kansas Basin (Rich, 1933) and the East-Central Iowa Basin (Bunker, 1981). Witzke (1981) and Bunker *et al.* (1983) described the East-Central Iowa Basin as a Silurian depositional basin, indicated by eastward (basinward) thickening of individual Silurian stratigraphic units within the outcrop belt.

Collinson and James (1969) considered the Middle Devonian rocks of eastern Iowa and northwestern Illinois the southeastern-most transgressive deposits of a vast seaway that extended northwestward into western Canada. Biogeographic similarity with age equivalent rocks of the Traverse Group in the Michigan Basin area also suggests partial to complete seaway connections to the east across the area of the Wisconsin Arch.

The earliest Kaskaskia unit (Bertram Formation) is limited to a small geographic area near the axial center of the East-Central Iowa Basin (fig. 5). Age relationships of the Bertram are not known with certainty, other than the fact that it lies unconformably on the Silurian carbonates and that it is, in turn, overlain by the Otis. Petrographic analysis by Sammis (1978) suggested that the Bertram was formed in "a very restricted nearshore to terrestrial environment with rapidly fluctuating conditions." Caliche fabrics noted by Sammis (1978) in the Bertram suggest meteoric-vadose calcite cementation in a deposit which accreted in a topographic depression developed on the Silurian erosion surface.

Areas of pre-Kaskaskia topographic relief developed on the Tippecanoe erosion surface as a result of differential erosional characteristics of the Silurian carbonates and the Upper Ordovician Maquoketa shales of eastern Iowa. Erosional escarpments, similar to the modern Niagaran Escarpment (Prior, 1976, p. 30) of northeastern Iowa developed at the pre-Kaskaskia erosional margins of the Silurian, and are believed to have served as effective barriers to open-marine circulation in the transgressing Middle Devonian seas. A stratigraphic profile using the top of the Wapsipinicon Formation as a datum (fig. 6) illustrates this surface of erosional relief and shows a generalized cross-sectional view of the East-Central Iowa Basin. Note the distribution of the Bertram Formation near the axial center of the subsident area that represents the East-Central Iowa Basin. The asymmetry of the Bertram suggests that basinal subsidence was probably related to penecontemporaneous faulting along the Plum River Fault Zone. Thus, both erosional and tectonically controlled topography influenced initial Kaskaskia deposition in the East-Central Iowa Basin area.

Regional overlap of the Bertram Formation by the Otis, and the progressive burial of Silurian erosional escarpments along the northern and southern margins of the East-Central Iowa Basin are also illustrated along the profile line (fig. 6). The Spillville Formation (noted on the profile as an "unnamed Otis equivalent") in northern Iowa is equivalent to and physically separated from the Otis by the northern pre-Devonian Silurian escarpment (Bremer High,

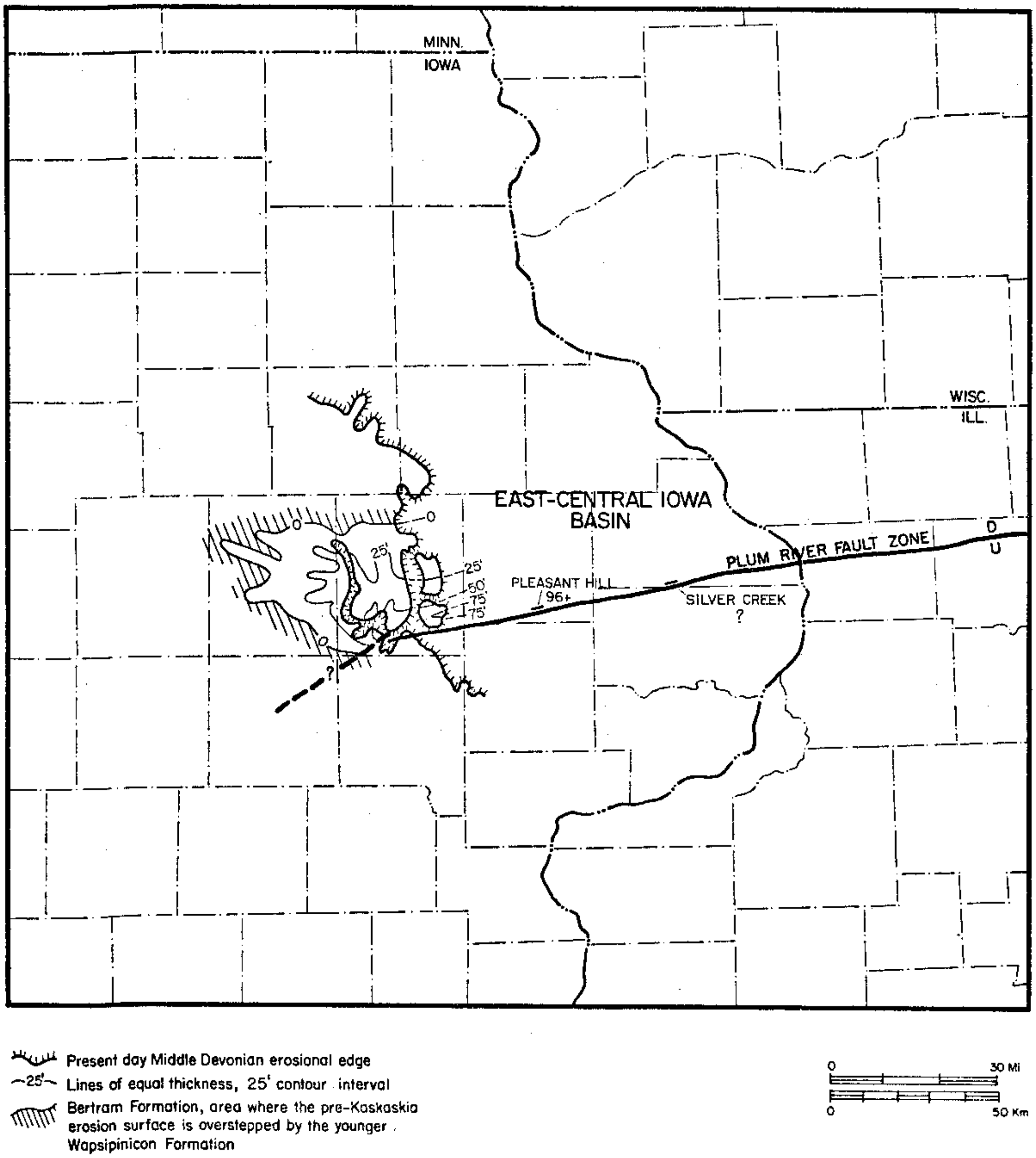


Figure 5. Isopach of the Bertram Formation in east-central Iowa (from Bunker *et al.*, 1983).

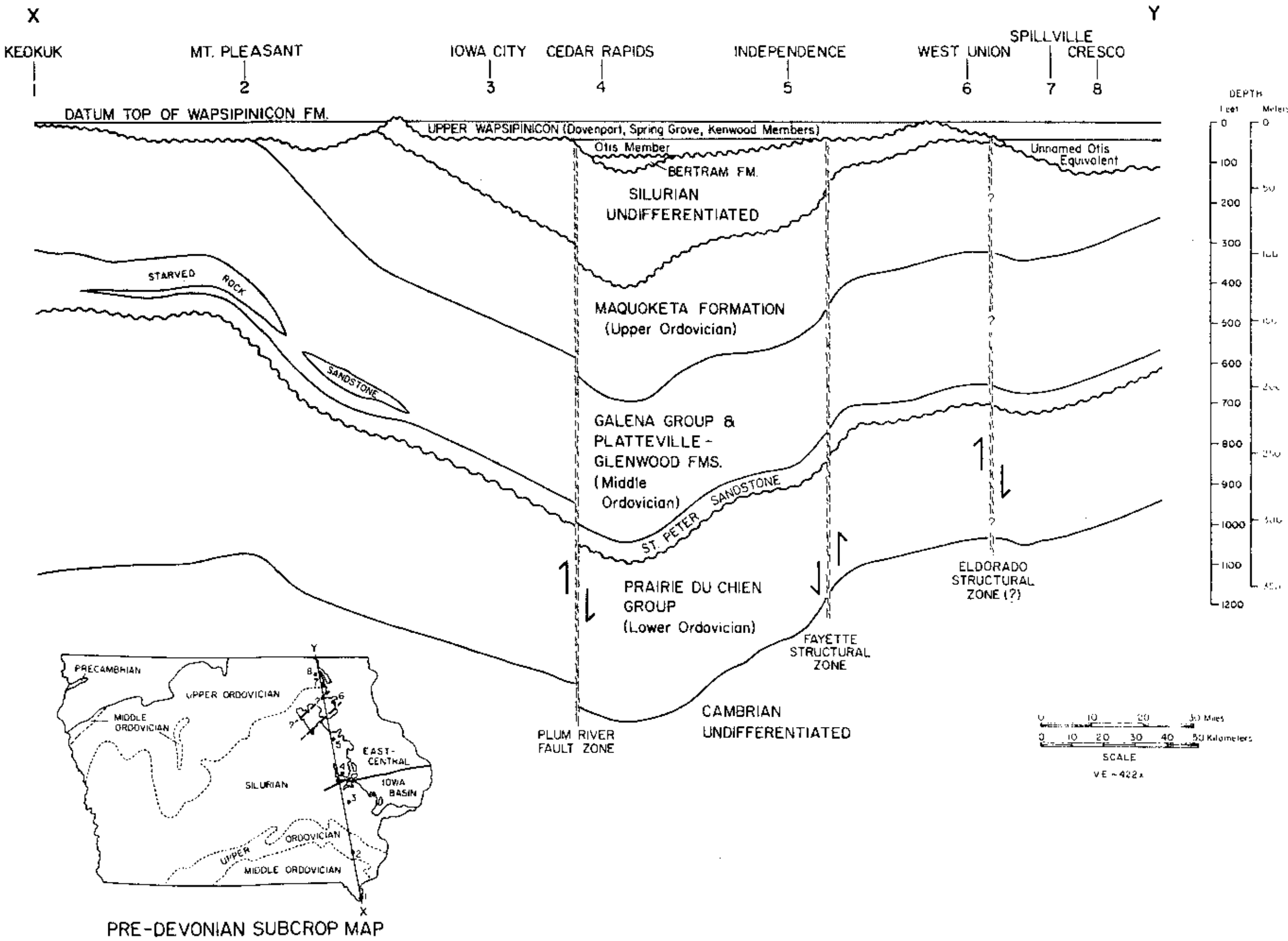


Figure 6. Generalized north-south stratigraphic cross-section, utilizing the top of the Wapsipinicon Formation (Middle Devonian) as the datum. The East-Central Iowa Basin is evident as a pre-Kaskaskia structural feature on this profile line (from Bunker *et al.*, 1983). The Spillville Formatin is the unnamed Otis equivalent noted on this profile line.

Bunker *et al.*, 1983; fig. 7). The Bremer High served as an effective barrier to the initial southward transgressing Middle Devonian seas. Open-marine conditions with a diverse biota (Spillville) characterized the region north of

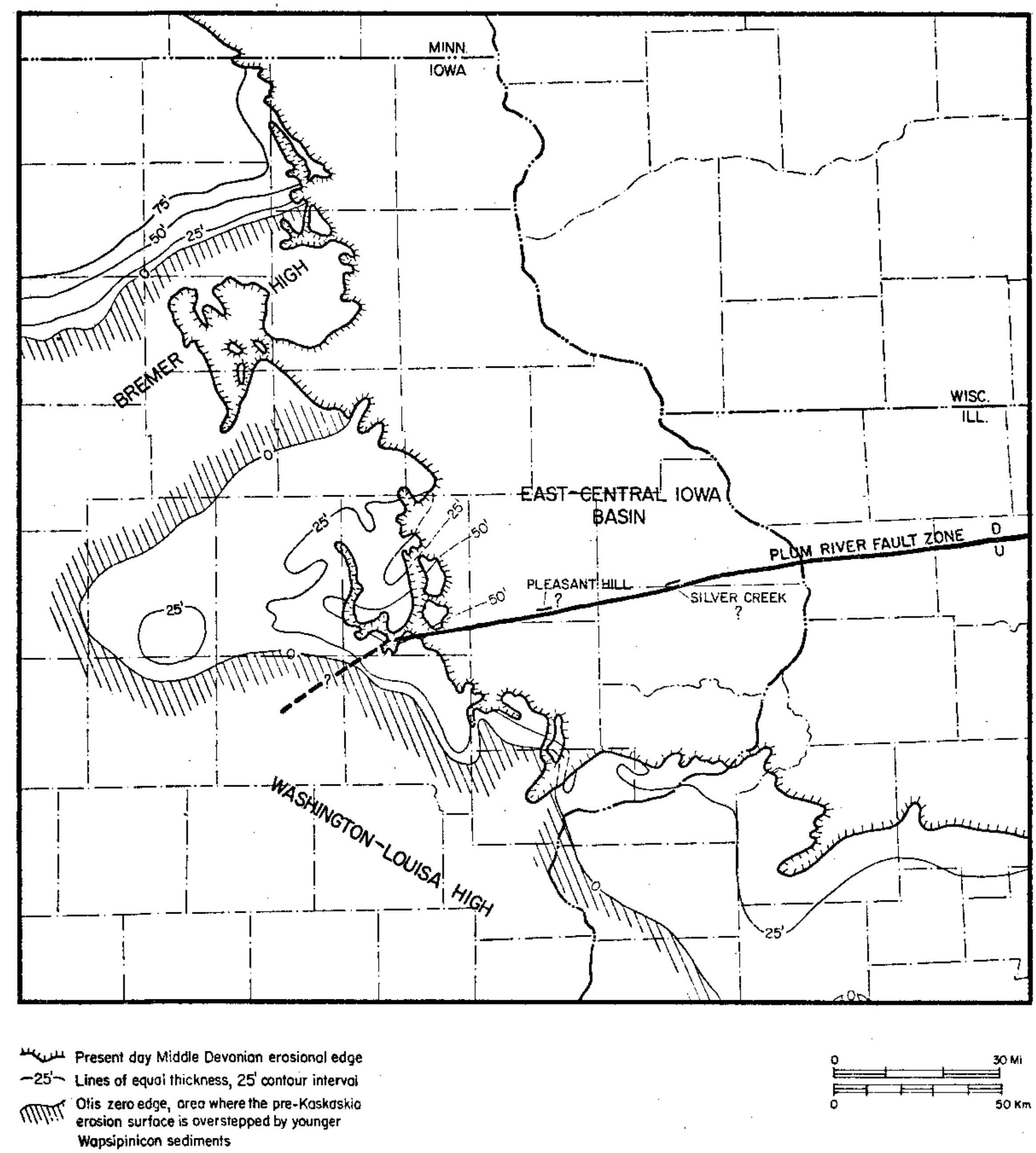


Figure 7. Isopach map of the Otis-Spillville (adapted from Bunker *et al.*, 1983).

the barrier, whereas more restricted marine conditions with a low-diversity fauna characterized Otis deposition in the East-Central Iowa Basin interior. An isopach map of the Spillville Formation and the Otis (fig. 7) shows their present geographic distribution across eastern Iowa. Comparison of the Otis-Spillville isopach (fig. 7) with the Bertram isopach (fig. 5) shows the degree of Otis overlap across the Bertram. The Otis isopach (fig. 7) also reflects eastward (basinward) thickening into the East-Central Iowa Basin area.

Expansion of the Middle Devonian sea following Otis deposition is evident on the stratigraphic profile (fig. 6). Regional onlap of the Kenwood, Spring Grove, and Davenport sediments overlapping the Otis, and progressive burial of the northern pre-Devonian Silurian escarpment (Bremer High) is illustrated. Encroachment upon a simlar escarpment (Washington-Louisa High, Bunker *et al.*, 1983; fig. 7) along the southern margin of the basin is also illustrated (fig. 6). These escarpments continued to play an effective part in the restriction of water circulation, which may have helped lead to the deposition of a Wapsipinicon gypsum-anhydrite evaporite sequence in eastern Iowa. Prior to the onset of Cedar Valley deposition, Wapsipinicon strata apparently were subjected to subaerial exposure and freshwater diagenesis as the Wapsipinicon sea regressed. Partial to complete dissolution of the gypsum-anhydrite evaporite interval in the Wapsipinicon ("Fayette Breccia," Norton, 1920) occurred within the East-Central Iowa Basin area prior to and contemporaneous with the initial transgression of the Cedar Valley sea.

The Rapid-Solon Members of the Cedar Valley Limestone represent the final transgressive expansion of the Middle Devonian seas (Taghanic onlap, Johnson, 1970; Klapper and Johnson, 1980) into the central midcontinent region. The Taghanic onlap marks the end of provincialism among brachiopods, corals, and trilobites across the North American continent. The southward overlap of the Wapsipinicon by the Cedar Valley has been mapped in central Illinois by James (1968) and Collinson and Atherton (1975).

Kettenbrink (1973) summarized the following depositional framework for the Cedar Valley: 1) fine sand (Hoing Sandstone) and fragments of the underlying Davenport calcilutites were incorporated into the initial Cedar Valley sediments (basal Solon); 2) continued expansion of the seas during the Solon resulted in deposition of fine- to medium-grained skeletal calcarenites with local development of coral or stromatoporoid-rich biostromes or shell banks; 3) slightly deeper water conditions with an increase in the influx of argillaceous material prevailed during the major transgressive phase of the Rapid; 4) a submarine disconformity marks the end of the Middle Devonian (Taghanic onlap) transgressive episode in eastern Iowa; and 5) the Coralville was deposited during a general regressive interval, and progressively shallower depositional environments are documented upward in the sequence (evaporites are noted at this horizon in the subsurface of central Iowa).

A period of post-Cedar Valley erosion and karstification in eastern Iowa and adjacent Illinois ensued prior to the Upper Devonian transgression into the region. In places, sinkholes and caverns developed in Middle Devonian and Silurian strata, and stratigraphic leaks of Upper Devonian shale (Independence Shale) infilled these karst features.

FURTHER STUDIES

Although recent petrographic, stratigraphic, and biostratigraphic studies have started to clarify the relationships of the Devonian sequence in northeast Iowa and adjacent areas, many outstanding problems remain. In particular, the invertebrate macrofauna of the Spillville Formation needs to be systematically described. Further paleontological studies could potentially provide insights on critical questions. For example, the Spillville brachiopod fauna needs to be compared with contemporary faunas in other regions. This information could provide a basis for biogeographic comparisons and potentially answer a basic question--What was the paleogeography of the Otis-Spillville seaway in Iowa with respect to adjacent areas? Stratigraphic relations strongly suggest that the initial Devonian transgression spread from northern regions into Iowa. However, extensive post-Devonian erosion has removed Devonian strata from the Transcontinental Arch and Wisconsin Dome areas, obscuring the physical relations--Do the Spillville brachiopods show closer relations to the Michigan or Williston Basin faunas, or both? To a large extent, the systematic paleontology of the Cedar Valley faunas of northern Iowa and southern Minnesota also remains to be described.

Additional stratigraphic and petrographic problems need to be addressed as well. For example--What clastic source terranes provided the terrigenous detritus noted in the "Lake Meyer" and Kenwood clastic units? What facies of the Wapsipinicon Formation are represented in Minnesota? What was the sequence of diagenetic events in the various stratigraphic units?

We wish to openly encourage anyone so inclined to pursue these fields of research on the intriguing Devonian sequence in northern Iowa.

ACKNOWLEDGEMENTS

We wish to gratefully acknowledge the cooperation of the Winneshiek County Conservation Commission--Lake Meyer Nature Center, J. F. Pavlovec Rock Co. Inc. of Calmar, Iowa, and Lloyd Pattison and Sons of Fayette, Iowa for permission to visit their properties. Appreciation is also accorded to many of the early geologists--in particular Calvin, Savage, and Norton--who first visited the area and meticulously recorded their observations on the geology of the area. Art Gerk of Mason City, Iowa referred the authors to the Devonian-Ordovician contact at Lake Meyer County Park (Stop 3) and his contribution is greatly appreciated. In addition, observations on the Fort Atkinson Member at Stop 4 by Barb Torney, University of Iowa, were shared with the authors, and we acknowledge her contributions. We also wish to thank Laurie Comstock for typing of the guidebook and Greg Ludvigson for his editorial review.

REFERENCES

Bayer, T. N., 1967, Repetitive benthonic community in the Maquoketa Formation (Ordovician) of Minnesota: Jour. Paleon., v. 41, p. 417-422.

Bunker, B. J., 1981, The tectonic history of the Transcontinental Arch and Nemaha Uplift and their Relationship to the Cretaceous Rocks of the Central Midcontinent Region: Iowa Geol. Surv., Guidebook Ser., no. 4, p. 1-23.

Bunker, B. J., Ludvigson, G. A., and Witzke, B. J., 1983, The Plum River Fault Zone and the structural and stratigraphic framework of eastern Iowa: Iowa Geol. Surv., Technical Info. Series, no. 12, in press.

Calvin, S., 1903, Geology of Howard County: Iowa Geol. Surv., Ann. Rept., v. 13, p. 21-79.

_____, 1906, Geology of Winneshiek County: Iowa Geol. Surv., Ann. Rept., v. 16, p. 39-146.

Chatterton, B. D. E., 1979, Aspects of Late Early and Middle Devonian conodont biostratigraphy of western and northwestern Canada: *in* C. R. Stelck and B. D. E. Chatterton (eds.), Western and Arctic Canadian Biostratigraphy: Geol. Assoc. Canada Special Paper 18, p. 161-231.

Cooper, G. A. *et al.*, 1942, Correlation of the Devonian sedimentary formations of North America: Geol. Soc. Am. Bull., v. 53, p. 1729-1793.

Church, N. K., 1967, Lithostratigraphy and carbonate-evaporite petrology of the Middle Devonian Wapsipinicon Formation in Iowa: unpub. M.S. thesis, Univ. of Iowa, 120 p.

Dorheim, F. H., and Campbell, R. B., 1958, Recent gypsum exploration in Iowa: Iowa Acad. of Sci., Proceedings, v. 65, p. 256-253.

Dorheim, F. H., and Koch, D. L., 1966, Devonian of northern Iowa, Cedar Valley, Shell Rock, and Lime Creek: Guidebook for 30th Ann. Tri-State Geol. Field Conf., 45 p.

Johnson, M. E., 1977, Community succession and replacement in Early Silurian platform seas: Ph.D. thesis, Univ. Chicago, 237 p.

Johnson, J. G., 1970, Taghanic onlap and the end of North American Devonian provinciality: Geol. Soc. Am. Bull., v. 81, p. 2077-2105.

Kettenbrink, E. C., 1973, Depositional and post-depositional history of the Devonian Cedar Valley Formation, east-central Iowa: unpub. Ph.D. dissertation, Univ. of Iowa, 191 p.

Keyes, C. R., 1912, Sundry provincial and local phases of the general geologic section of Iowa: Iowa Acad. Sci., Proceedings, v. 19, p. 147-151.

Klapper, G., and Barrick, J. E., 1983, Middle Devonian (Eifelian) conodonts from the Spillville Formation in northern Iowa and southern Minnesota: Jour. Paleont., in press.

Klapper, G., and Johnson, J. G., 1980, Endemism and dispersal of Devonian conodonts: Jour. Paleont., v. 54, p. 400-455.

Klapper, G,. and Ziegler, W., 1979, Devonian conodont biostratigraphy: *in* M. R. House, C. T. Scrutton, and M.G. Bassett (eds.), The Devonian System: Special Papers in Palaeontology 23, p. 199-224.

Koch, D., and Michael, B., 1965, Pre Cedar Valley post Maquoketa sediments in northeast Iowa: Geol. Soc. of Iowa, Guidebook, 19 p.

Kohls, D. W., 1961, Lithostratigraphy of the Cedar Valley Formation in Minnesota and northern Iowa: unpub. Ph.D. dissertation, Univ. of Minn., 200 p.

Ladd, H. S., 1929, Stratigraphy and paleontology of the Maquoketa Shale of Iowa: Iowa Geol. Survey, Ann. Rept., v. 34, p. 305-448.

Mossler, J. H., 1978, Cedar Valley Formation (Devonian) of Minnesota and northern Iowa: Minn. Geol. Surv., Rept. of Inv., no. 18, 44 p.

Norton, W. H., 1895, Geology of Linn County: Iowa Geol. Surv., Ann. Rept., v. 4, p. 121-195.

_____, 1920, Wapsipinicon breccias of Iowa: Iowa Geol. Surv., v. 27, p. 360-549.

Norris, A. W., Uyeno, T. T., and McCabe, H. R., 1982, Devonian rocks of the Lake Winnepegosis-Lake Manitoba outcrop belt, Manitoba: Geol. Surv. Canada Mem. 392, 280 p.

Orr, R. W., 1971, Conodonts from Middle Devonian strata of the Michigan Basin: Indiana Geol. Surv. Bull. 45, 110 p.

Parker, M. C., Dorheim, F. H., and Campbell, R. B., 1959, Resolving discrepancies between surface and subsurface studies of the Maquoketa Formation of northeast Iowa: Proc. Iowa Acd. Sci., v. 66, p. 248-256.

Pearson, S. G., 1982, Depositional environments, diagenesis and barite mineralization of the Middle Devonian Wapsipinicon Formation in Fayette County, Iowa: unpub. M.S. thesis, Univ. of Iowa, 203 p.

Prior, J. C., 1976, A regional guide to Iowa landforms: Iowa Geol. Surv., Ed. Ser. 3, 72 p.

Raasch, G. O., 1935, Devonian of Wisconsin: Kansas Geol. Soc., Guidebook 9th Ann. Field Conference, p. 261-267.

Rich, J. L., 1933, Distribution of oil pools in Kansas in relation to pre-Mississippian structure and area geology: Am Assoc. Petrol. Geol. Bull., v. 17, p. 793-815.

Sammis, N. C., 1978, Petrology of the Devonian Wapsipinicon Formation from a core and reference exposures, central-eastern Iowa: unpub. M.S. thesis, Univ. of Iowa, 232 p.

Savage, T. E., 1905, Geology of Fayette County: Iowa Geol. Survey, Ann. Rept., v. 15, p. 433-546.

_____, 1914, The relations of the Alexandrian Series in Illinois and Missouri to the Silurian section of Iowa, Am. Jour. Sci., v. 38, p. 28-37.

_____, 1926, Silurian rocks of Illinois, Geol. Soc. Am. Bull., v. 37, p. 513-534.

Schumacher, D., 1971, Conodonts from the Middle Devonian Lake Church and Milwaukee Formations: *in* D. L. Clark (ed.), Conodonts and biostratigraphy of the Wisconsin Paleozoic: Wisconsin Geol. and Nat. Hist. Surv. Inf. Circular 19, p. 55-67, 90-99, 132-141.

Scobey, E. H., 1935, The Alexandrian problem in Iowa, M.S. thesis, Univ. of Iowa, 39 p.

Sendlein, L. V. A., 1964, Geology of the Sperry Mine, Des Moines County, Iowa: unpub. Ph.D. dissertation, Iowa State Univ., 79 p.

_____, 1968, Geology of the U.S. Gypsum Company's Sperry Mine, *in* Steinhilber, W. L., ed., 2nd Ann. Mtg., North-Central Sec., Geol. Soc. Am., Guidebook, Field trip 2, 17 p.

_____, 1972, Geology of the U.S. Gypsum Sperry, Iowa Mine, Devonian gypsum of Iowa: *in* Proceedings, Eighth Forum of Geology of Industrial Minerals: Iowa Geol. Surv., Pub. Info. Circ., no. 5, p. 67-87.

Sloss, L. L., 1963, Sequences in the Cratonic Interior of North America: Geol. Soc. Am. Bull., v. 74, p. 93-114.

Stainbrook, M. A., 1935, Stratigraphy of the Devonian of the Upper Mississippi Valley: Kansas Geol. Soc., Guidebook, 9th Ann. Field Conf., p. 248-260.

_____, 1941, Biotic analysis of Owen's Cedar Valley limestones: Pan Amer. Geol., v. 75, p. 321-327.

Stauffer, C. R., 1922, The Minnesota Devonian and its relationship to the general Devonian problem of North America: Am. Jour. Sci., 5th Ser., v. 4, Art. XXXV, p. 396-412.

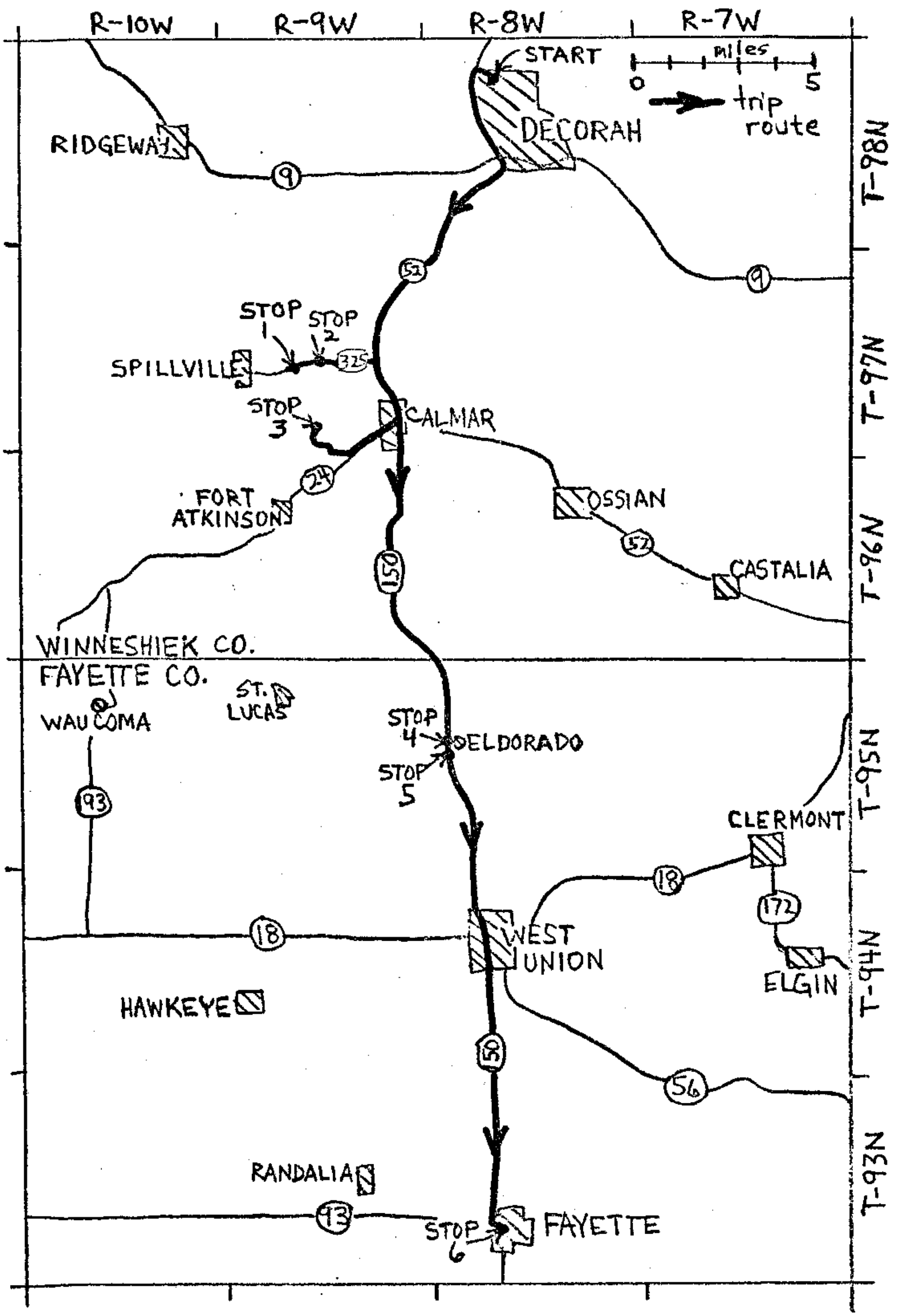
Uyeno, T. T., 1979, Devonian conodont biostratigraphy of Powell Creek and adjacent areas, western District of MacKenzie: *in* C. R. Stelck and B. D. E. Chatterton (eds.), Western and Arctic Canadian Biostratigraphy: Geol. Assoc. Canada Special Paper 18, p. 233-257.

Weddige, K, 1977, Die Conodonten der Eifel-Stufe im Typusgebiet und in benachbarten Faziesgebieten: Senckenbergiana lethaea, v. 58, p. 271-419.

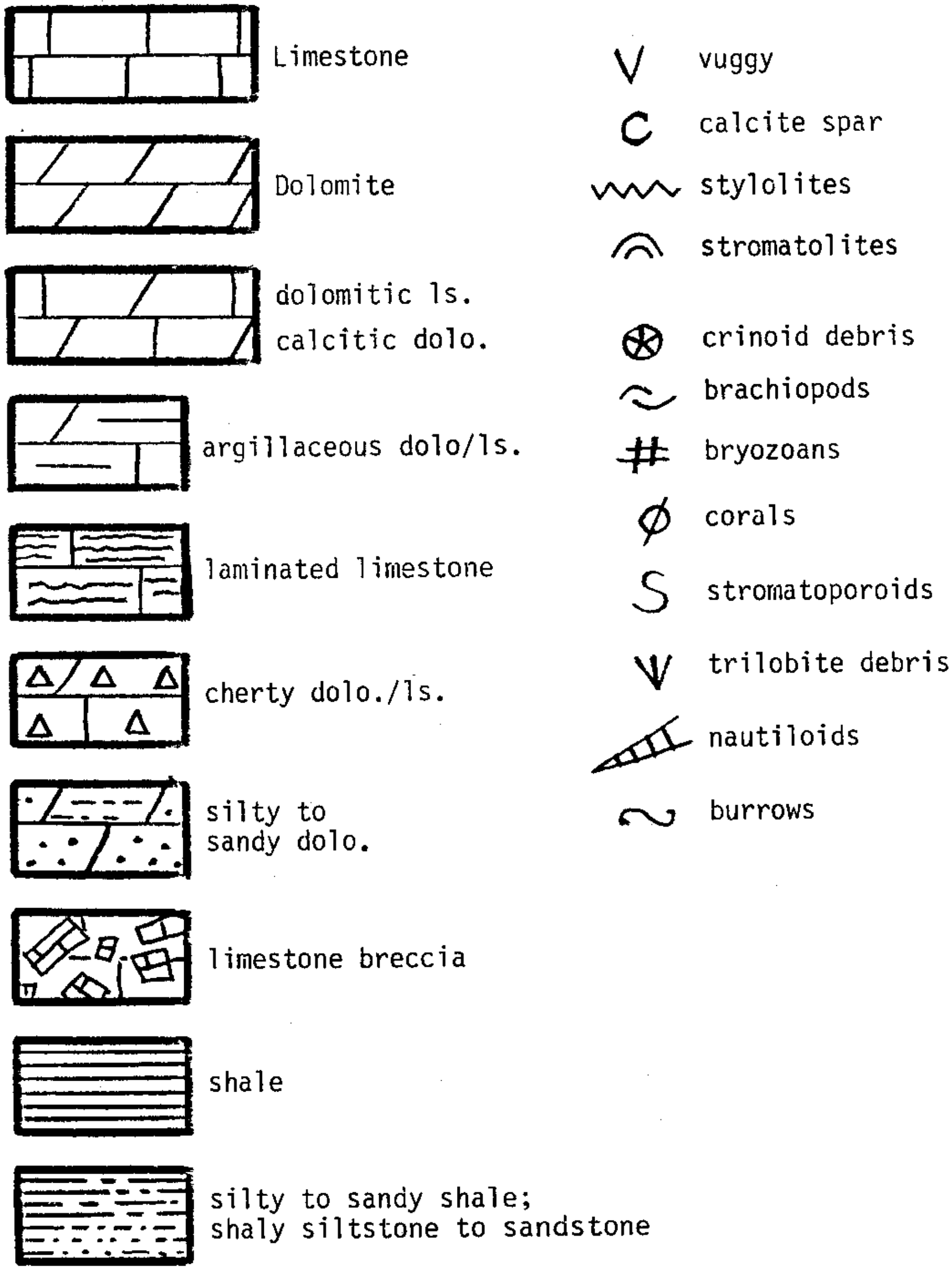
Witzke, B. J., 1981, Stratigraphy, depositional environments, and diagenesis of the eastern Iowa Silurian sequence, Ph.D. thesis, Univ. Iowa, 574 p.

Ziegler, W., and Klapper, G., 1982, Devonian Series boundaries: decisions of the IUGS Subcommission: Episodes, v. 1982, no. 4, p. 18-21.

NOTES



Map showing field trip route and stops.



Symbols used on stop sections.

ROAD LOG AND STOP DESCRIPTIONS

Mileage

0.0	Luther College, Nustad Parking Lot. Leave parking lot onto Poole Street and turn left onto College Drive.
0.4	Road divides, bear to the left onto Pole Line Road.
1.0	Intersection with Highway 52. Turn left and continue to the south.
1.3	Crossing the Upper Iowa River.
1.7-1.9	Galena Group road cut on right.
2.0-2.1	Galena Group road cuts on both sides of Highway 52.
2.3-2.4	Galena Group road cuts on both sides of Highway 52.
2.5	Bridge over Twin Springs Park.
2.6	Galena Group road cut.
2.8	Galena Group road cut on both sides of Highway 52.
3.1	Intersection of Highway 52 with Highway 9.
3.2-3.5	Galena Group road cut on right side of Highway 52. Railroad cuts in valley to left.
5.1	Iowa DOT maintenance shop on right.
7.4	Roadside exposures to left. Maquoketa Formation(?).
8.6	Roadside exposures. Maquoketa Formation(?).
10.6	Intersection with Highway 325. Turn right towards Spillville.
11.8-12.0	Devonian roadside exposures to right.
12.3-12.4	Devonian exposures to the right.
12.6	Devonian exposure in farmyard to the right.
12.7	Devonian roadside exposures.
13.0	STOP 1. Spillville Quarry. Park in quarry or area to south of Highway 325.

STOP 1. Spillville Quarry; type locality of the Spillville Formation (Klapper and Barrick, 1983).

We will assemble on the south side of the highway opposite the quarry entrance to examine basal Spillville strata exposed in the ditch area. Although most of the basal Spillville is covered at this locality, a fractured bedding surface reveals its general character. The exposed rock is a sandy to very sandy dolomite containing angular clasts of chert derived from the underlying Fort Atkinson Member of the Maquoketa Formation. The basal covered interval is overlain by about 2 m of prominently-bedded, dense dolomite containing scattered molds of echinoderm debris; this interval is accessible in the roadside exposures.

Proceed into the quarry area; please be particularly cautious along the quarry faces. Above the dense dolomite beds, the character of the Spillville Formation changes markedly, becoming massive and vesicular. The interval exposed in the lower half of the quarry contains a variety of fossil molds; brachiopods, crinoid debris, trilobite fragments, solitary and colonial corals, tentaculitids, and gastropods have been noted. This interval was termed the "*Productella* beds" by Calvin (1903). We encourage trip participants to collect macrofossils from these beds for future study.

Strata exposed in the upper half of the quarry are generally difficult to access along the quarry faces. The upper dolomite interval is lithologically similar to the underlying unit, although large masses of calcite commonly fill in irregular void spaces within the rock. Bedding becomes more prominent upward in the sequence. Calvin (1903) noted the conspicuous development of calcite masses in the upper part of the interval now referred to the Spillville Formation, and Dorheim (Iowa Geol. Survey files) informally referred to these beds as the "lower calcite zone." Fossil molds occur throughout the upper interval of the Spillville Formation, and crinoid debris, corals, brachiopods, and gastropods are noted.

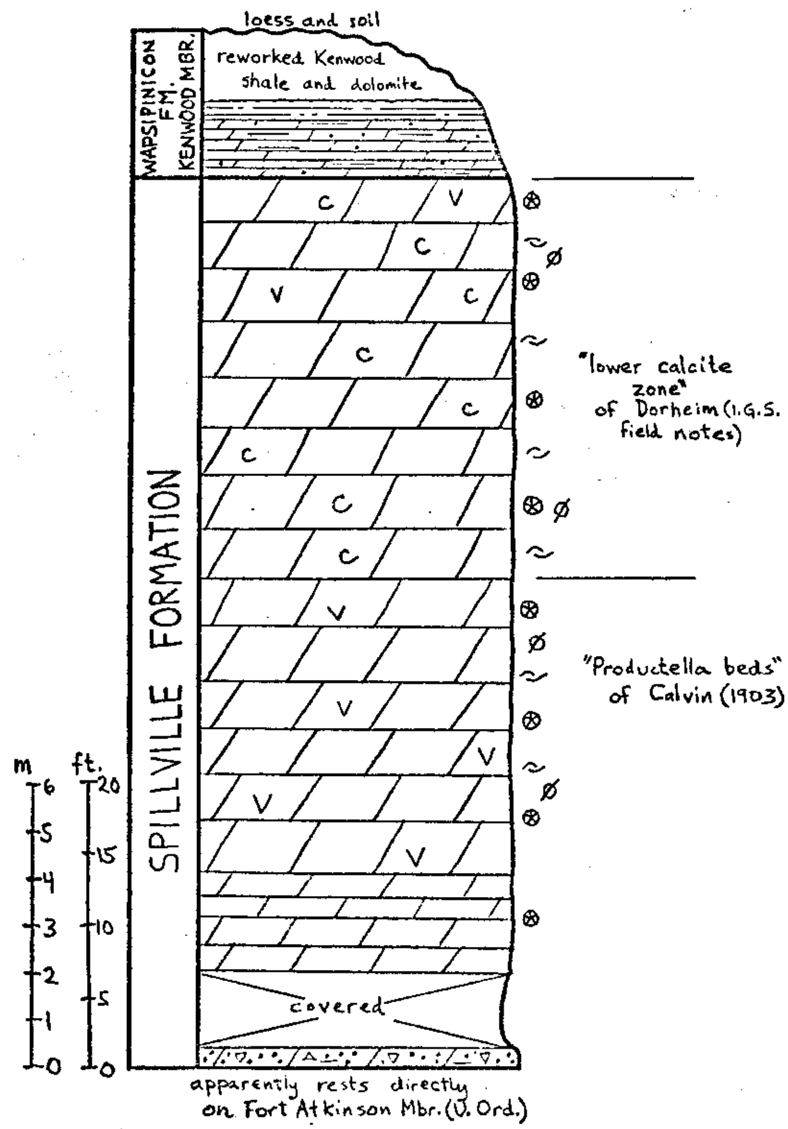
13.0 Return to Highway 325 and head back to the east.

13.8 Turn left onto gravel road and park along roadway. Walk back to Highway 325 and uphill to STOP 2. Be careful of traffic along highway.

STOP 2. Exposures along the north edge of Highway 325; Spillville, Wapsipinicon, and Cedar Valley Formations.

The base of the stratigraphic section exposed at this stop overlaps with the upper interval at Stop 1. The upper Spillville sequence is accessible in the western part of the outcrop. The overlying Kenwood Member of the Wapsipinicon is, for the most part, a covered to poorly-exposed interval, although the basal portion is exposed above the Spillville outcrops.

To resume the section, move to the next set of outcrops immediately to the east. The Davenport-Spring Grove interval is accessible above the Kenwood slope. The Wapsipinicon exposures are crumbly and hazardous, so please be



STOP 1. Spillville Quarry, Winneshiek County, SE NE SE sec. 20 and SW NW SW sec. 21, T97N, R9W.

extremely cautious. The Davenport-Spring Grove contact is not readily picked in the sequence, and the members are undifferentiated in this report. However, the lower 4.4 m of this interval contains bedded to brecciated petroliferous laminated carbonates, lithologies characteristic of the Spring Grove Member across much of eastern Iowa. The upper 3 m, probably equivalent to part or all of the Davenport Member, differs in some respects from characteristic Davenport lithologies southward in Iowa, primarily in lacking lithographic limestones and in containing more argillaceous material.

The easternmost exposures reveal the Wapsipinicon-Cedar Valley contact. The basal Cedar Valley is a fossiliferous limestone that has yielded conodonts characteristic of the basal Cedar Valley interval elsewhere in Iowa.

STOP 2. Highway 325 road cut 2 1/2 miles west of Spillville
SE SE NE sec. 21 and SW SW NW sec. 22, T-97N, R-9W, Winneshiek Co.
Composite section; thicknesses in meters above base of section.
Measured by B. J. Witzke, B. J. Bunker, G. Klapper.

CEDAR VALLEY FORMATION

15.25-16.05. Limestone, fine to medium grained skeletal wackestone to packstone; a few scattered quartz sand grains in lower portion; bedding 5-15 cm; crinoid debris and silicified brachiopods noted; includes 10 cm of limestone float at top.

WAPSIPINICON FORMATION--DAVENPORT-SPRING GROVE MEMBERS

12.2-15.25. Limestone, dolomitic, very fine crystalline, porous and vuggy; includes scattered to abundant breccia clasts to 5 cm; clasts are soft, very argillaceous limestone which weather out to form vugs; 40 cm from top, laterally discontinuous light brown laminated limestone bed noted; upper contact sharp.

11.2-12.2. Laterally variable unit; light brown laminated limestone, petroliferous, replaced laterally by non-laminated, finely crystalline limestone; upper 10 cm includes microbreccia with clasts to 5 cm, not continuous laterally.

10.3-11.2. Lower part is limestone, light brown, faintly laminated, slightly petroliferous; upper part is prominently laminated limestone, petroliferous, with some domal features (2 cm amplitude, possibly stromatolitic?).

9.1-10.3. Limestone, finely crystalline, horizontally bedded in part; partly brecciated with laminated limestone clasts 1 mm to 20 cm; microbreccia at top of unit; to the east the unit becomes a megabreccia.

7.75-9.1. Megabreccia, chaotic unit; clasts 2 to 90 cm; clasts include finely crystalline laminated limestone, slightly petroliferous, and porous dolomitic limestone with calcite spar fill; megabreccia discontinous, replaced laterally, in part, by light brown laminated limestone, slightly petroliferous.

WAPSIPINICON FORMATION--KENWOOD MEMBER

7.4-7.75. Dolomitic limestone, argillaceous, with scattered quartz sand grains.

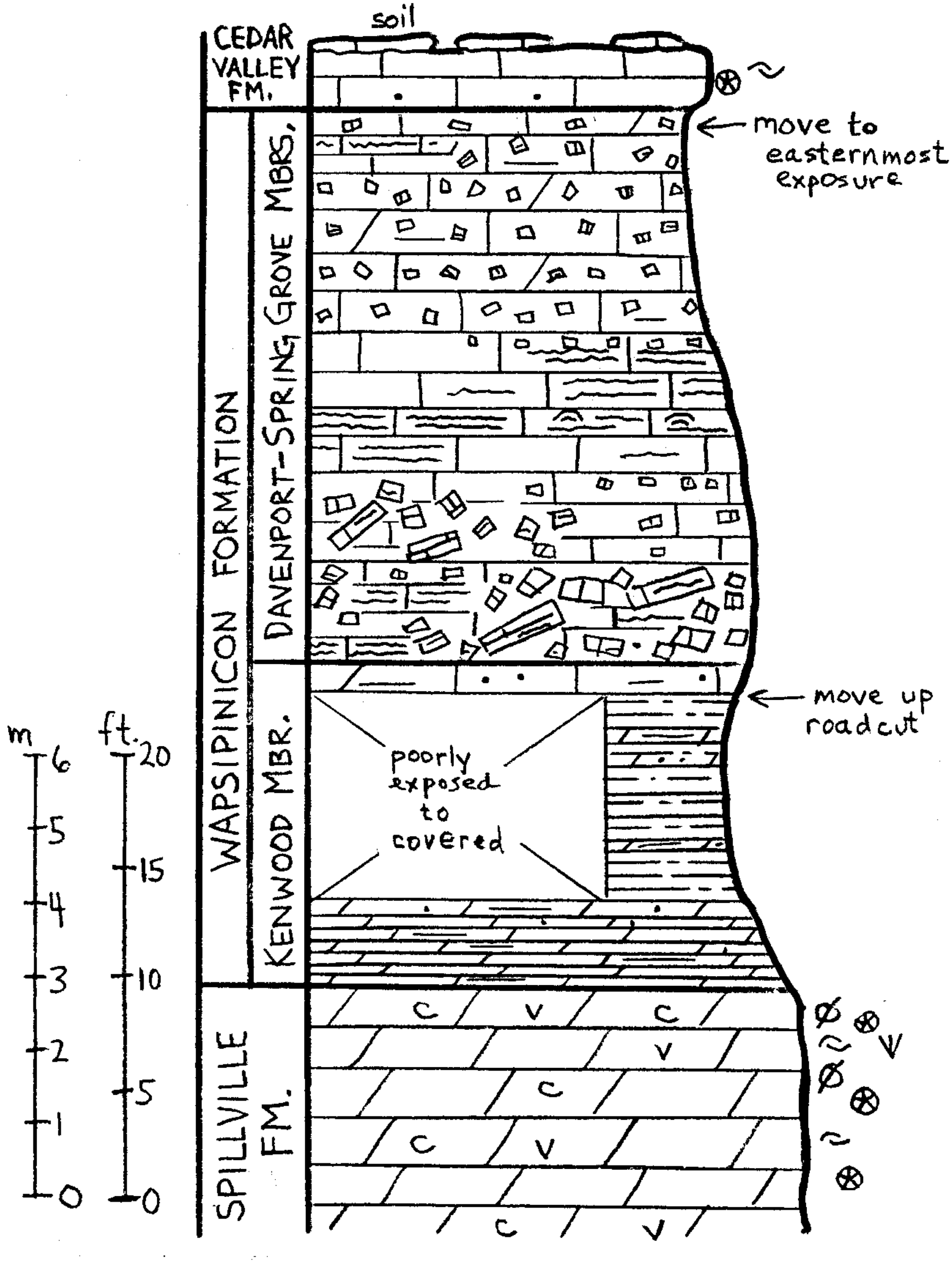
4.55-7.4. Poorly exposed interval; characteristic lithologies include:
1) thin-bedded argillaceous dolomite, partly silty to sandy, and
2) shale, light yellow orange, calcareous, partly silty to sandy.

4.1-4.55. Dolomite, slightly argillaceous, thin bedded (5-10 cm), calcite spar void fill in places, scattered quartz sand grains.

3.3-4.1. Dolomite, microcrystalline to very finely crystalline, slightly argillaceous, thin bedded (5 cm).

SPILLVILLE FORMATION

0-3.3. Dolomite, extremely finely crystalline, scattered fossil-molds (moldic wackestone texture), part vuggy, scattered to abundant calcite spar void fill; fossil molds include crinoid debris, brachiopods, trilobites (*Dechenella* cf. *D. alpenensis* noted 60 cm from top), solitary rugosans, and tabulate corals (*Favosites* colonies to 25 cm diameter in bed 50 cm from top). Poorly exposed near base of section.



STOP 2. Highway 325 road cut, Winneshiek County, SE SE NE sec. 21 and SW SW NW sec. 22, T97N, R9W.

13.8 Turn around and return to Highway 325. Continue to the east.

15.3 Junction of Highway 325 and 52. Turn right onto Highway 52.

17.1 Calmar, Iowa. Junction of Highways 150, 24, and 52. Turn right on Highway 24 and follow to the west.

18.8 Turn right on gravel road to Lake Meyer County Park.

19.6 Turn right on gravel road.

19.8 Road splits, bear to left into park.

20.6 Lake Meyer Dam. Pull off along roadway. STOP 3 at north end of dam.

STOP 3. Lake Meyer County Park; Maquoketa (Fort Atkinson)-Spillville contact.

The Spillville Formation rests directly on the Fort Atkinson Member of the Maquoketa Formation at this locality, as it apparently does at Stop 1. The basal 1.6 m of the Spillville is primarily a terrigenous clastic unit, composed of silty to sandy mudstone and argillaceous siltstone and very fine grained sandstone. The basal sequence is dolomitic or calcareous to varying degrees. This clastic interval is informally labelled the "Lake Meyer member" in this report. Spillville dolomites overlie the basal clastics. The carbonate sequence closely resembles that present at Stop 1; 1.6 m of dense, bedded dolomite is abruptly overlain by rubbly-appearing vesicular dolomite.

20.6 Continue on park roadway to east.

20.9 Lake Meyer Nature Center. Turn around and follow road back out of park.

23.0 Intersection with Highway 24. Turn left and return to Calmar.

24.7 Junction Highways 150, 24, and 52. Turn right on Highway 150 and continue south.

25.3 Northeast Iowa Technical Institute on right.

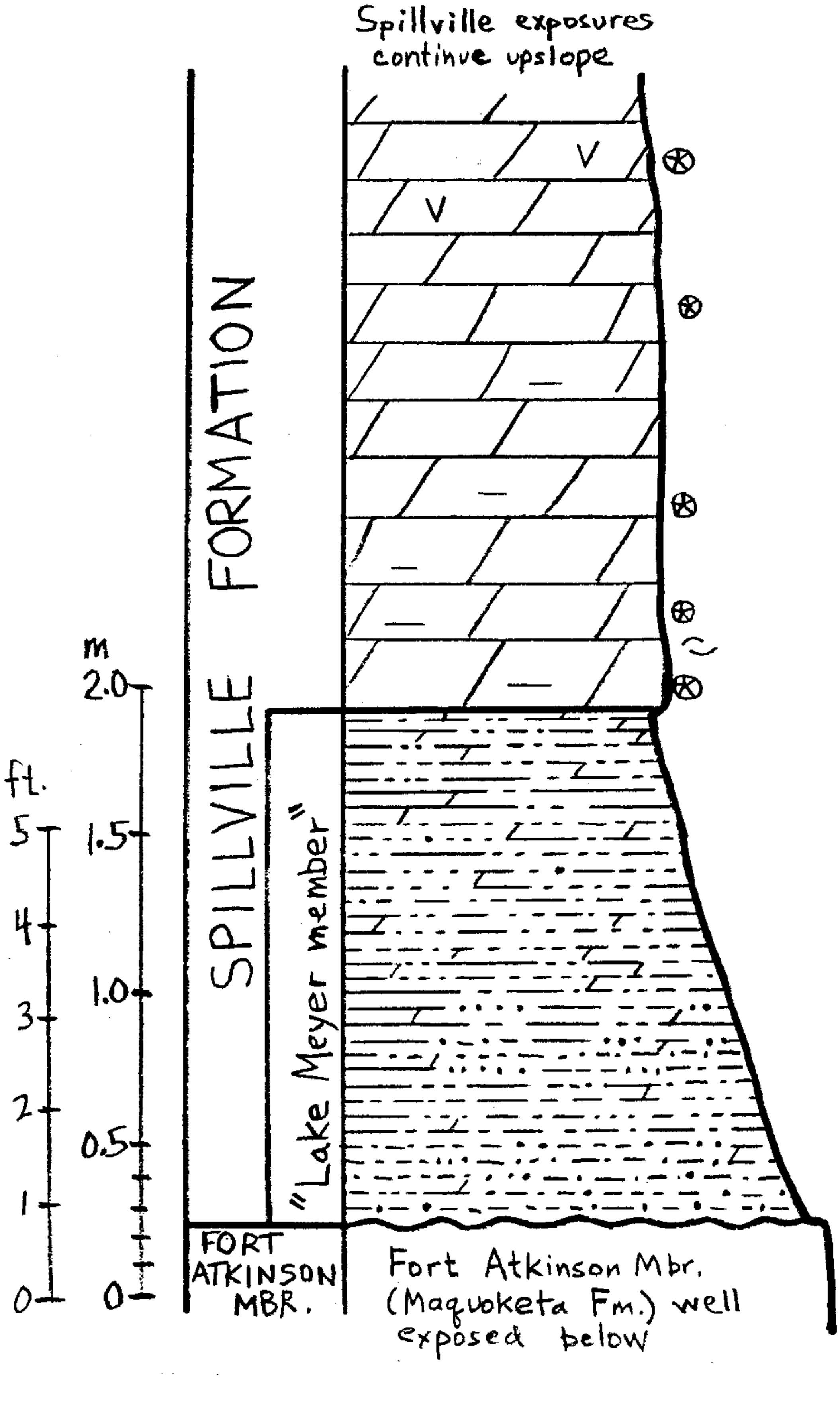
26.2 Outcrops on right.

26.6 Outcrops on right.

28.4 Intersection with B52 west. Stay on Highway 150 and continue south.

28.6 Festina Quarry on left. Fort Atkinson Member.

28.8-28.9 Outcrops on both sides of highway. Fort Atkinson Member.



STOP 3. Lake Meyer County Park, Winneshiek County, SW SW SW NE sec. 33, T97N, R9W.

29.1 Festina. Outcrops on left, Fort Atkinson Member. Intersection with B52 east. Continue south on Highway 150.

29.3-29.6 Scattered outcrops on both sides of highway.

31.9 Small quarry on hill to left.

32.2 Fayette County line. Continue south on Highway 150.

32.4-32.7 Outcrops and road cuts on both sides of highway.

34.4 Crossing Turkey River. Town of Eldorado to left.

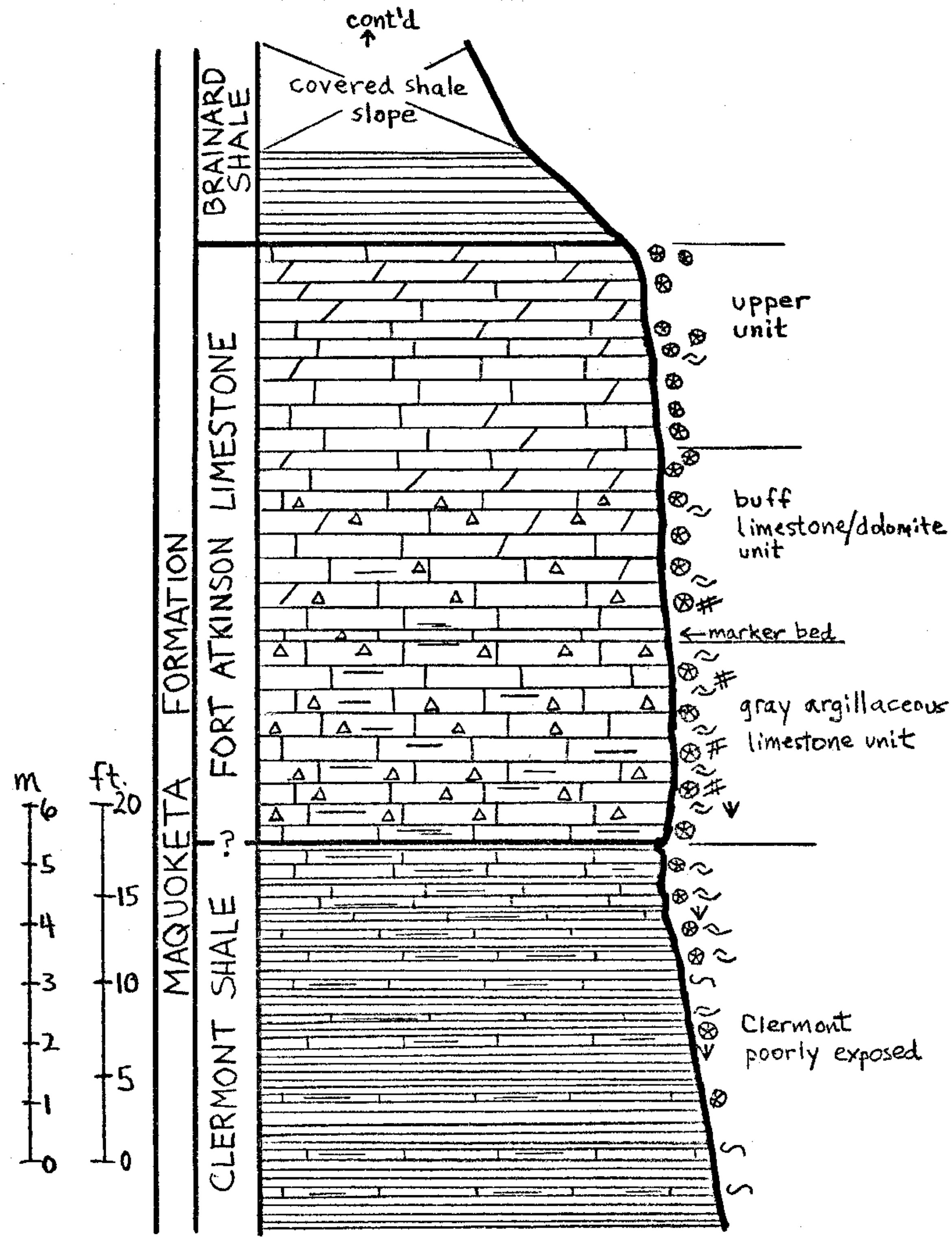
34.5 Turn right on gravel road and park. STOP 4.

STOP 4. Highway 150 road cut south of Turkey River bridge at Eldorado; Maquoketa Formation--Clermont, Fort Atkinson, and Brainard Members.

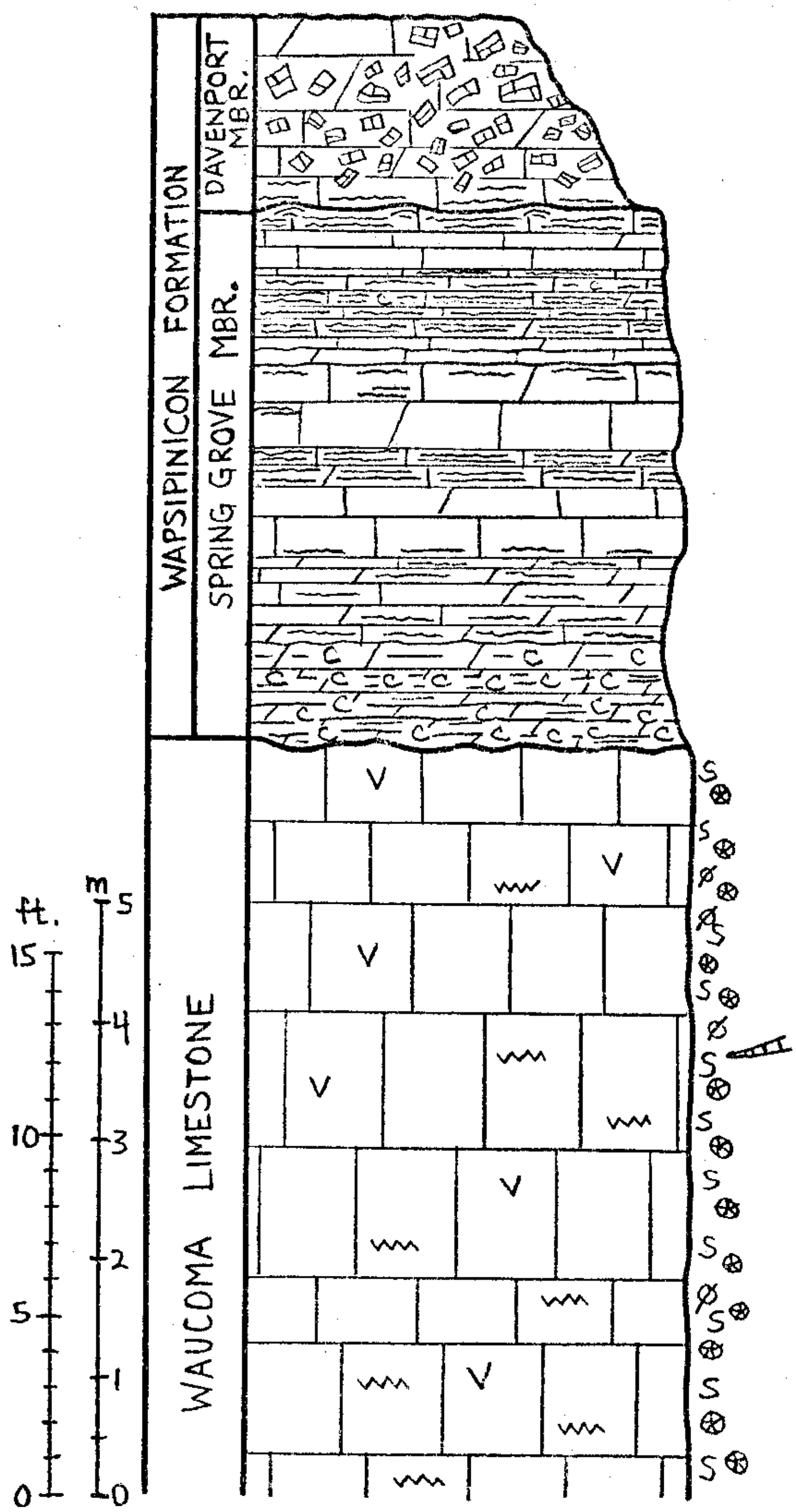
Although the Fort Atkinson Member is directly overlain by Devonian strata at Stop 3, Brainard shales and Silurian limestones intervene between the Fort Atkinson Member and the Devonian sequence at this locality (Stops 4 and 5). The sequence exposed at Stop 4 begins in the Clermont Shale Member of the Maquoketa Formation, but most of the Clermont is poorly exposed. Argillaceous limestone interbeds in the upper Clermont at this locality have yielded a variety of well-preserved fossils, including brachiopods, trilobites, and articulated crinoids and cystoids.

The entire Fort Atkinson Member is accessible at Stop 4, and the generalized stratigraphic succession is illustrated on the next page. Illustrated thicknesses are approximate. The Fort Atkinson sequence is informally divided into three units: 1) A lower gray argillaceous limestone unit with nodular chert bands; most limestones have wackestone texture, and fossils are well preserved. Shaly partings are noted along wavy bedding surfaces. Common fossils include brachiopods (some strophomenids to 10 cm), bryozoans, trilobites, and abundant crinoidal debris (some articulated remains). 2) A buff limestone and dolomite unit (dolomitic limestone and calcitic dolomite) containing scattered to abundant chert nodules. This unit is markedly less argillaceous than the interval below. A distinctive 18 cm marker bed occurs at the base of the unit that consists of dense limestone that breaks with conchoidal fracture. Additional beds similar to the basal marker occur higher in the unit; these beds have a pelleted microtexture (B. Torney, 1983, pers. comm.). The unit is variably fossiliferous, and some thin crinoidal packstone-grainstone beds occur. 3) An upper unit of dolomitic limestone and calcitic dolomite. Coarse crinoidal debris is prominent in some beds, and crinoidal grainstone beds are noted. Overall, the Fort Atkinson Member appears to be a shallowing-upward carbonate sequence at this locality.

The Fort Atkinson Member is overlain by the Brainard Shale Member south of the main carbonate outcrops. About 1.5 m of basal Brainard shale is exposed; the gray-green dolomitic shales lack macrofossils and contain small argillaceous dolomite concretions. The thick Brainard Shale (25-35 m) forms a prominent covered slope beneath the Silurian escarpment.



STOP 4. Highway 150 road cut, Eldorado, Fayette County, SE NW NW sec. 18, T95N, R8W.



STOP 5. Highway 150 road cut, Goeken Park, Fayette County, SW NE SW sec. 18, T95N, R8W.

34.5 Continue ahead on gravel road.

34.7 Bear to the right at split in road and loop back around to left, return to highway.

35.2 Highway 150 intersection. Turn right.

35.9 Goeken Park. Turn right into park. Lunch stop and STOP 5.

STOP 5. Goeken Park road cut; Waucoma and Wapsipinicon Formations.

The Silurian escarpment rises above the Brainard Shale slopes at Goeken Park, where the Silurian and Devonian sequence is well exposed along Highway 150. Although the Silurian interval over most of eastern Iowa is a dolomite sequence, the Silurian exposures at Goeken Park are composed of limestones preserving original sedimentary fabrics. These limestones are assigned to the Waucoma Formation which, at this locality, is probably equivalent to dolomites of the Tete des Morts and Blanding(?) Formations farther south in Fayette County. The Waucoma Limestone exhibits a crinoidal wackestone to packstone texture throughout the interval, and it is, in part, stylolitic and vuggy with some calcite spar filling. Disc-shaped stromatoporoids make up a significant portion of the rock volume, and cup corals, colonial corals (*Favosites*), brachiopods, and nautiloids are also present. The limestone is very thickly bedded, and indistinct burrow-mottled textures are recognized.

The Wapsipinicon Formation unconformably overlies Silurian strata at Goeken Park, and the Spillville Formation and Kenwood Member (Wapsipinicon Fm.) are absent at this locality due to non-deposition. The basal 90 cm of the Devonian sequence is an argillaceous dolomite interval that contains abundant calcite spar filling; this interval is included in the basal Spring Grove Member. Pearson (1982) reported barite veinlet mineralization in this zone. Laminated petroliferous limestones are interbedded with non-laminated limestones in the remainder of the Spring Grove Member. The upper bedding surface of the Spring Grove Member is marked by low-amplitude circular stromatolites about 10 cm in diameter.

The uppermost interval at Goeken Park is assigned to the Davenport Member and includes dolomitic limestones and limestone breccias. The breccias contain clasts up to 18 cm long; the clasts are composed of laminated limestone and dense lithographic limestone.

We will discuss the observed Devonian and sub-Devonian stratigraphic relations seen so far on the trip, and attempt to draw some paleogeographic conclusions. It is appropriate to note at this point, some Devonian stratigraphic relations observed elsewhere in northeast Iowa. Limestone breccias of the Davenport Member are observed directly overlying Silurian strata (Waucoma Limestone) and beneath the Cedar Valley Formation in the vicinity of Waucoma (northeast Fayette County). In Bremer County (near Denver) the Cedar Valley Formation rests directly on Silurian strata (Hopkinton Fm.). Why are the Spillville Formation and various members of the Wapsipinicon Formation absent in portions of the Fayette-Bremer County area?

35.9 Return to Highway 150. Turn right and continue south.

41.4 West Union. Intersection with Highways 150 and 18. Continue south on Highway 150.

45.8 Cedar Valley Limestone road cuts.

46.9 Volga Recreation area to left. Continue south on Highway 150.

47.5 Cedar Valley Limestone stream cut to left and hog lot exposure to right.

49.0 Cedar Valley Limestone exposures.

49.0 Crossing Volga River. Cedar Valley Limestone exposures at north end of bridge.

49.2 Fayette. Turn left onto West Water Street, first road south of Volga River bridge.

49.4 Turn right onto Mechanic Street. Continue south.

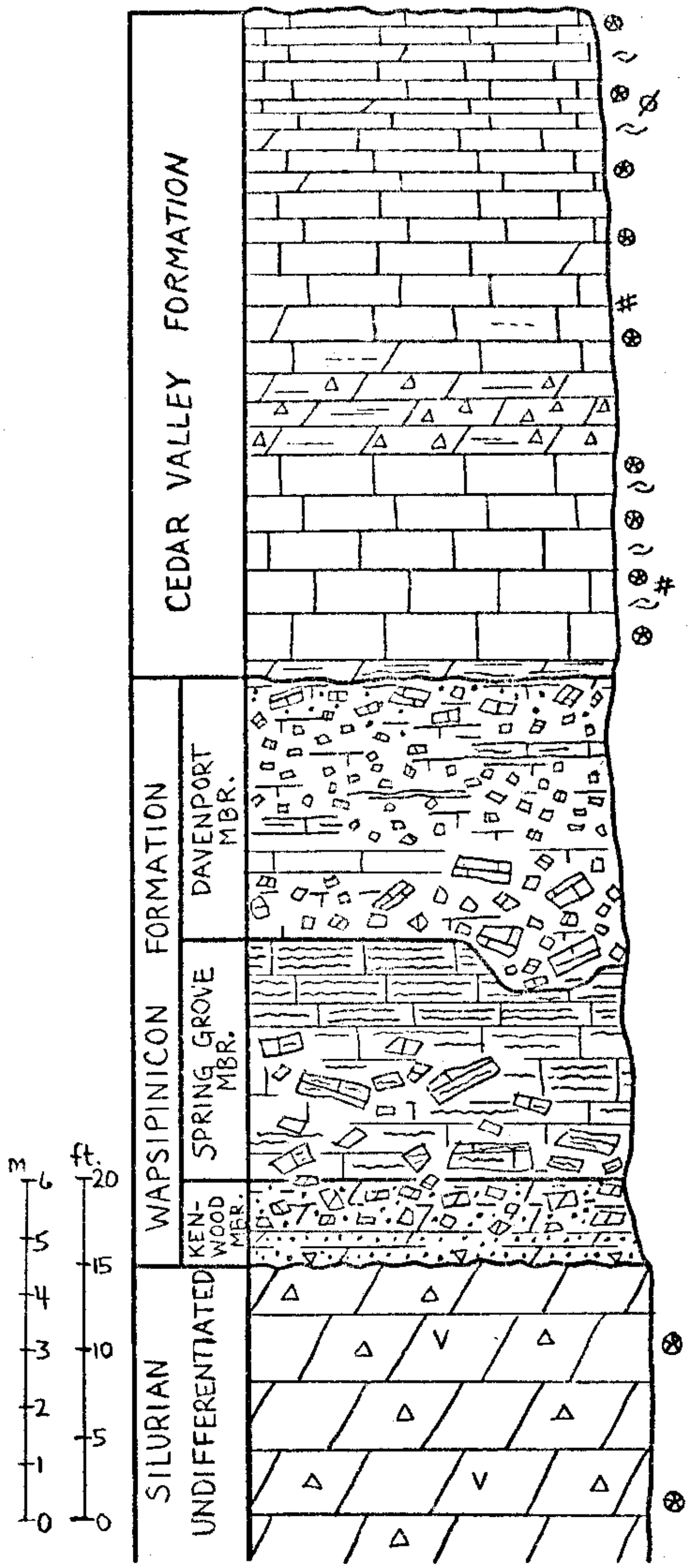
50.0 Bear right into quarry.

50.2 Fayette Quarry. STOP 6. This quarry is owned and operated by Lloyd Pattison and Sons. It began operating in 1928. Please be careful!

STOP 6. Fayette Quarry; Silurian dolomite, Wapsipinicon and Cedar Valley Formations.

We will examine the Silurian-Devonian sequence exposed in the southeastern part of the quarry area. The sequence begins at water level in the flooded portion of the quarry; please be extremely cautious along the quarry walls. The Wapsipinicon Formation directly overlies Silurian strata at this locality, but some significant differences are noted between the stratigraphic sequences at Stops 5 and 6. Silurian limestones of the Waucoma Formation are noted at Stop 5, but the limestone sequence is replaced southward by a Silurian dolomite interval. Cherty dolomite, probably equivalent to a portion of the Blanding or Hopkinton Formation, is accessible at the base of the Fayette Quarry section.

The basal 1.6 m of the Wapsipinicon Formation is assigned to the Kenwood Member, a clastic-rich unit not seen at Stop 5, but present at Stops 1-2. The Kenwood in Fayette Quarry is divided into two subunits: 1) A basal 60 cm, very sandy argillaceous dolomite and calcareous sandstone interval; reworked Silurian chert clasts are present at the base. 2) A 1 m thick dolomitic limestone breccia; clasts (most less than 2 cm) are dolomitic limestone and argillaceous dolomite in a sandy dolomitic matrix.



STOP 6. Fayette Quarry, Fayette County, SE SE SE sec. 29, T93N, R8W.

As at Stop 5, the Spring Grove Member at the Fayette Quarry includes characteristic laminated petroliferous limestones. However, limestone megabreccias also occur at this locality within the Spring Grove that include laminated limestone clasts up to 1 m in diameter. Up to 1 m of relief is developed on the Spring Grove surface beneath the Davenport Member.

The Davenport Member ("Fayette breccia") at the Fayette Quarry is dominantly a limestone breccia including both microbreccias (clasts less than 2 cm) and megabreccias (clasts up to 40 cm). The clasts are composed of dense lithographic limestone, a characteristic lithology of the Davenport Member at most localities. Bedded lithographic limestone, laterally replaced by breccia, is noted in the lower part of the member. The limestone matrix of the breccia units is less resistant than the clasts and is, in part, argillaceous. It includes some scattered shale stringers; the matrix becomes extremely sandy in the upper 60 cm.

The Cedar Valley Formation at the Fayette Quarry does not closely resemble the better studied sequence in the Iowa City area. Fossiliferous limestones in the lower part of the Fayette Quarry sequence are overlain by an unfossiliferous dolomite interval containing nodular chert bands and shaly partings along bedding. Sparsely fossiliferous dolomitic limestones occur above the cherty interval. The uppermost portion of the quarry is a fossiliferous, thin to medium bedded limestone interval. Correlation of the Fayette County Cedar Valley sequence with the various members of the Cedar Valley Formation in Johnson County has not yet been established. Most or all of the Fayette Quarry Cedar Valley section apparently correlates to the Solon Member. It is not known if equivalents of the Rapid Member are present in the quarry, and the uppermost portions of the quarry sequence may alternatively be Rapid or Solon equivalents. Additional conodont and petrographic studies may clarify some of these relationships.