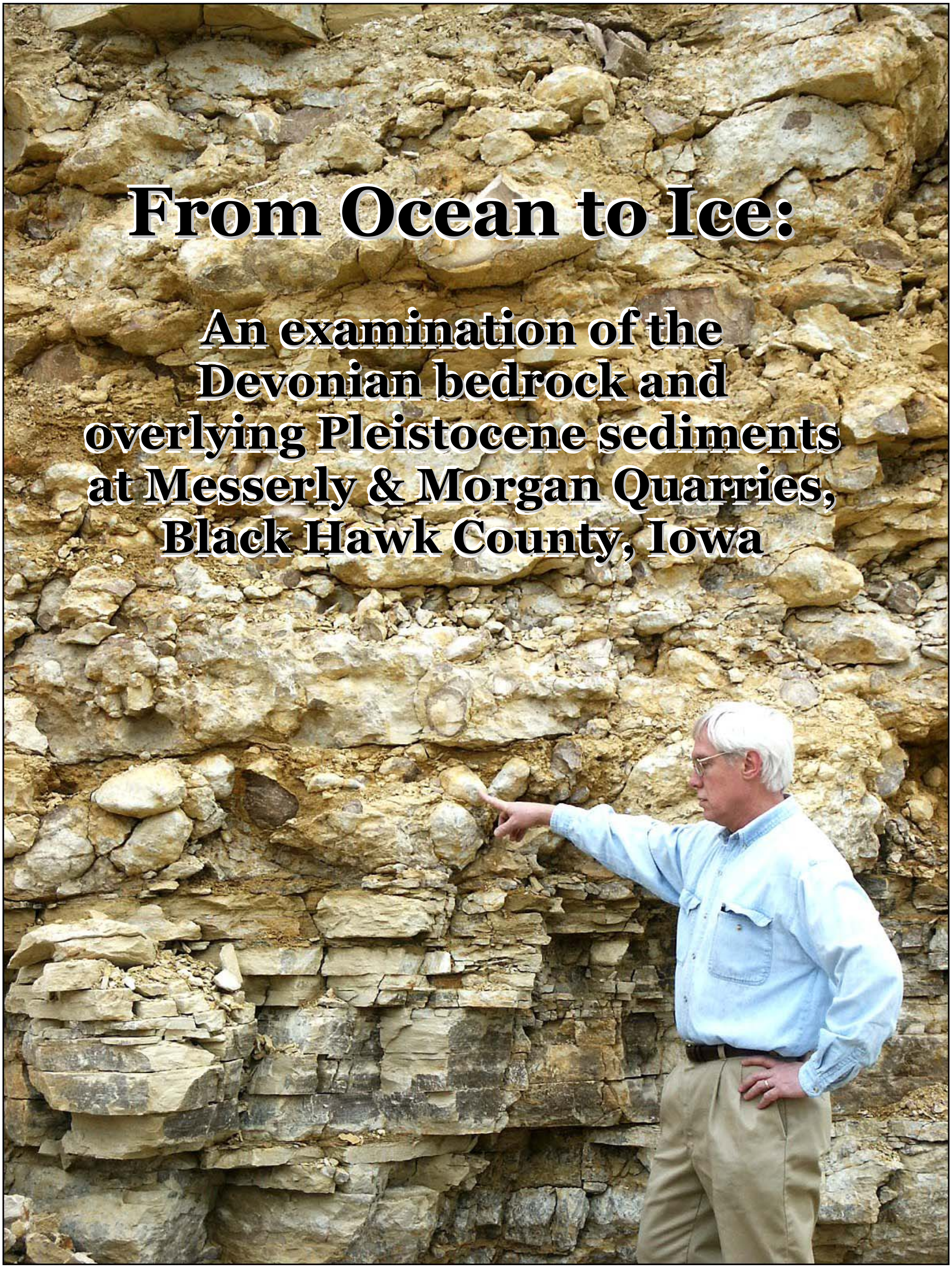
From Ocean to Ice:

An examination of the Devonian bedrock and overlying Pleistocene sediments at Messerly & Morgan Quarries, Black Hawk County, Iowa



Geological Society of Iowa

April 24, 2004 **Guidebook 75**

Cover photograph : University of Northern Iowa Professor and field trip leader Dr. Jim Walters points to a stromatoporoid-rich bed in the Osage Springs Member of the Lithograph City Formation at the Messerly Quarry, the first stop of this field trip

From Ocean to Ice: An examination of the Devonian bedrock and overlying Pleistocene sediments at Messerly & Morgan Quarries, Blackhawk County, Iowa

prepared and led by:

James C. Walters
Department of Earth Science
University of Northern Iowa
Cedar Falls, IA 50614

John R. Groves
Department of Earth Science
University of Northern Iowa
Cedar Falls, IA 50614

Sherman Lundy
4668 Summer St.
Burlington IA 52601

with contributions by:

Bill J. Bunker
Iowa Geological Survey
Iowa Department Natural Resources
Iowa City, Iowa 52242-1319

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

April 24, 2004

Geological Society of Iowa
Guidebook 75

TABLE OF CONTENTS

INTRODUCTION TO FROM OCEAN TO ICE: AN EXAMINATION OF THE DEVONIAN BEDROCK AND OVERLYING PLEISTOCENE SEDIMENTS AT MESSERLY & MORGAN QUARRIES, BLACKHAWK COUNTY, IOWA

Raymond R. Anderson
Iowa Geological Survey
Iowa Department of Natural Resources
Iowa City, Iowa 52242-1319

Today's field trip marks the return of the GSI Spring Field Trip's association with the Annual Meeting of the Iowa Academy of Science. For many years the Iowa Academy's Annual Meeting traveled around the state, hosted by local colleges and universities. In those times the GSI Spring Field Trip followed the Academy, always departing from the current host institution and examining nearby geological features. Then, some years ago, a faltering Academy budget forced the organization to establish a permanent home for their Annual Meeting at the Hotel Fort Des Moines. Rather than continuing to run field trips in the same area, the GIS severed its association with the IAS Annual Meeting and began to visit other areas with its Spring trips. Now that the Academy is again on the road with their Annual Meetings, the GSI Spring Field Trip joins it. This year's Spring trip departs the University of Northern Iowa, next year we will be at Cornell College, in 2006 at Buena Vista University, and in 2007 the trip will depart Central College.

Basic Materials Corp Messerly Quarry; field trip Stop 1.

The Spring 2004 GSI field trip will be a half-day trip to two quarries that display the rich geology of the Cedar Falls area. Our first stop will be the **Messerly Quarry** near Finchford north of Cedar Falls. There we will see the Pre-Illinoian tills of the Iowan Surface overlying the Devonian limestones and shale of the Lithograph City Fm (Cedar Valley Gp), with its spectacular exposure of "stromglomerate". Stop 2 is the **Morgan Quarry**, just east of Waterloo, where 2 Pre-Illinoian tills overly glacially polished and striated limestones of the Solon Mbr of the Little Cedar Fm and underlying Pinicon Ridge Fm of the Wapsipinicon Gp. We greatly appreciate the access to these fine quarries provided by **Basic Materials Corp** and the assistance of their geologist, Sherman Lundy. We are planning a beautiful day and hope that all participants will have a pleasant learning experience For your safety and the best enjoyment of this field trip, I encourage you to follow the instructions of the trip leaders.

AN UPPER MIDDLE THROUGH LOWER UPPER DEVONIAN LITHOSTRATIGRAPHIC AND CONODONT BIOSTRATIGRAPHIC FRAMEWORK OF THE MIDCONTINENT CARBONATE SHELF AREA, IOWA

Bill J. Bunker and Brian J. Witzke
Iowa Geological Survey
Iowa City IA 52242-1319

reprinted from Iowa Geological Survey Guidebook Series No. 16

INTRODUCTION

Epicontinental seaway shelves are generally characterized by repetitive episodes of progradation, punctuated by periods of transgression and subsequent flooding of the seaway margins. These episodes are generally recognized along epicontinental shelves as transgressive-regressive (T-R) cycles. The basic stratigraphic framework of the Iowa Middle Devonian Wapsipinicon and Cedar Valley groups are defined as a series of carbonate T-R cycles (Witzke *et al*., 1988), which occur along the western margin of the Middle to Late Devonian Chattanooga Sea. These sequences in the Upper Midwest occur in an area that has been termed the Midcontinent Carbonate Shelf by Slingerland (1986), who modeled tidal effects in the Late Devonian seaway. A conodont zonation scheme for cratonic biofacies in eastern Iowa has also been developed (Bunker and Klapper, 1984; Witzke *et al*., 1985; Witzke *et al*., 1988), which provides a basis for correlation in the Midcontinent Carbonate Shelf area.

Devonian strata in Iowa and surrounding areas unconformably overlie an eroded surface of Ordovician and Silurian rocks (Fig. 1). Upper Devonian strata onlap onto the Precambrian surface adjacent to the Sioux Ridge in northwestern Iowa (Fig. 1). Devonian strata in the central Midcontinent region are bounded to the north by the Transcontinental Arch (including the Sioux Ridge), to the west by the Cambridge Arch-Central Kansas Uplift, to the south by the Chautauqua Arch-Ozark Uplift-Sangamon Arch, and to the east by the Devonian outcrop belt and sub-Pennsylvanian Devonian edge (Figs. 1, 2). Devonian strata extend across the Transcontinental Arch in the area of the Nebraska Sag (Fig. 1). Devonian seaways may also have breached the arch to the east of the resistant highlands of the Sioux Ridge in central Minnesota, but pre-Cretaceous erosion apparently removed Devonian strata from that area. The East-Central Iowa and North Kansas basins (Fig. 1) are primarily Silurian features, but persisted as structural depressions during the initial stages of Middle Devonian (late Eifelian-early Givetian) deposition in the region. Eifelian deposits are restricted to these two basin areas and are absent from intervening areas in central and western Iowa. Late Givetian and Frasnian strata thicken markedly toward central and northern Iowa, where the thickest sequences of Devonian strata in the region are preserved (to 230 m). Total Devonian isopachs delineate this area as a stratigraphic basin (Fig. 2), termed the Iowa Basin by Witzke *et al*. (1988). Although the thick accumulation of Devonian strata in the Iowa Basin delineates a region of significant Devonian subsidence, deposition in this basin area was dissimilar to that in the central Illinois Basin. As will be discussed, the Iowa Basin encompassed an area of extensive shallow-marine, tidal-flat, and evaporite deposition during the late Middle through lower Upper Devonian. Depositional interpretations indicate that consistently shallower-water depositional facies are found in the central area of the Iowa Basin than are found in either southeastern Iowa or in the central Illinois Basin, and as such it is not considered to be a bathymetric basin during Devonian deposition (Witzke *et al*., 1988). By contrast, the Illinois Basin was a site of relatively deeper-water epicontinental sedimentation during much of the Devonian (Witzke, 1987). The central Illinois Basin is regarded, therefore, as both a bathymetric and a stratigraphic basin.

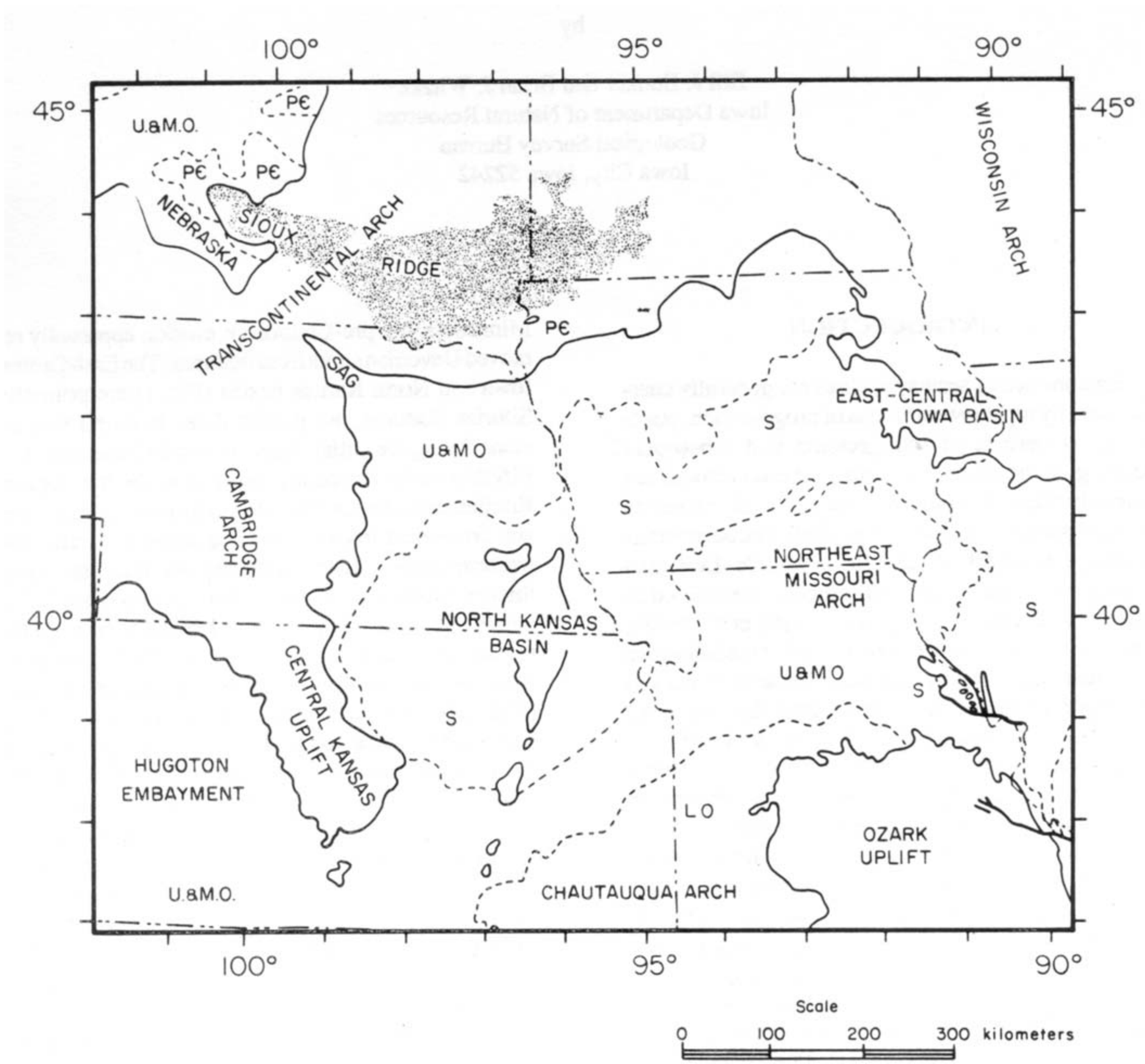


Figure 1. Pre-Kaskaskia paleogeographic map of the central mid-continent region, USA. (from Bunker *et al*., 1988). P-Precambrian; LO-Lower Ordovician: U&MO-Upper & Middle Ordovician; S-Silurian.

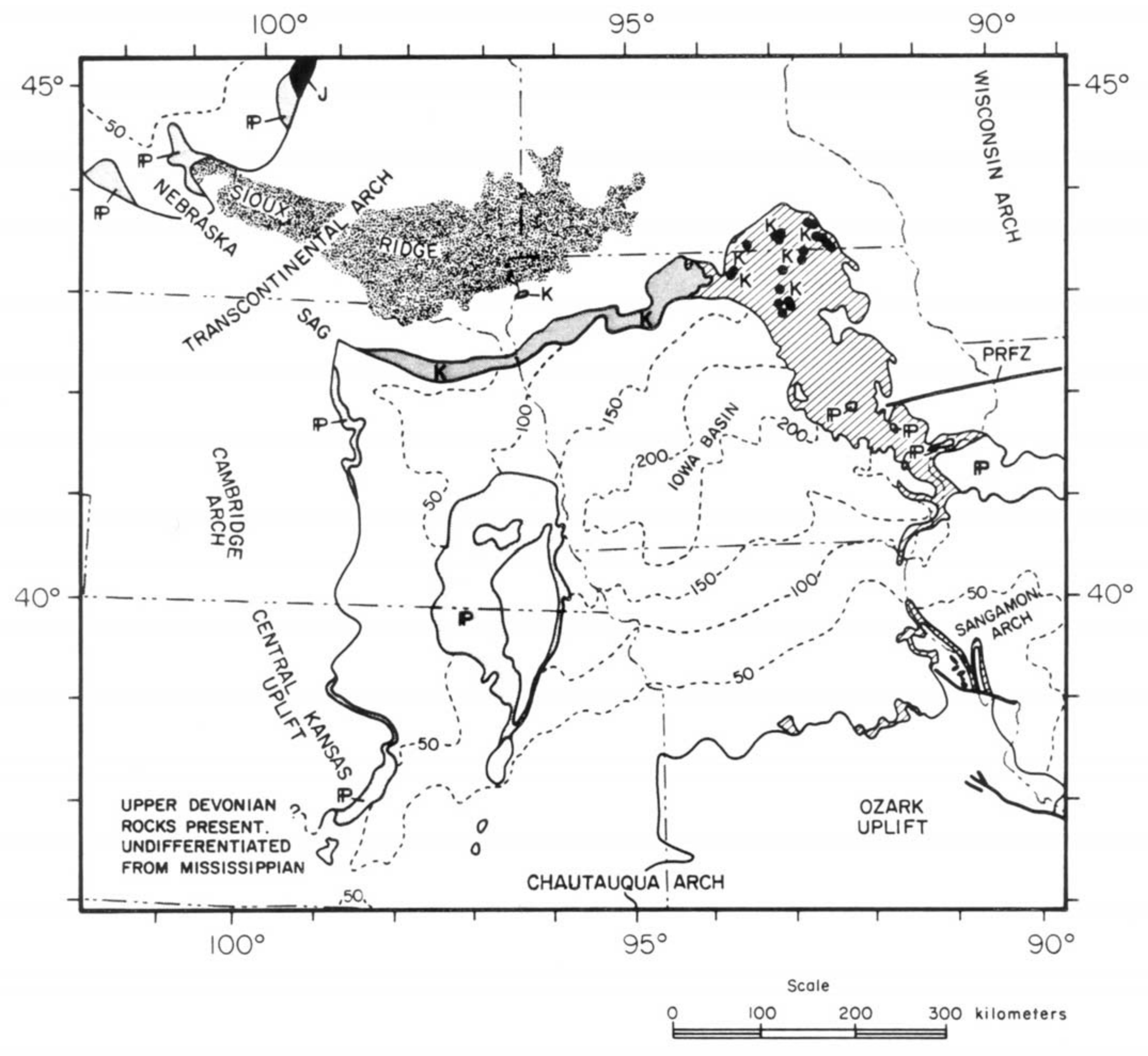


Figure 2. Total Devonian isopach map of the central midcontinent region, USA (from Bunker *et al*., 1988). Contour interval is 50 m. Patterned areas denote where Devonian strata have been eroded and overstepped by younger strata. P-Pennsylvanian; J-Jurassic; K-Cretaceous; diagonally-lined areas denote present day outcrop. PRFZ-Plum River Fault Zone.

STRATIGRAPHY

Wapsipinicon Group

The Wapsipinicon Formation was named by Norton (1895) for exposures along the Wapsipinicon River in northeastern Linn County, Iowa. It was elevated to group status by Witzke *et al*. (1988) to include, in ascending order, the Bertram, Otis, and Pinicon Ridge formations in eastern Iowa, and the Spillville and Pinicon Ridge formations in northern Iowa and southeastern Minnesota (Fig. 3).

The Wapsipinicon Group overlies an erosional surface on Ordovician and Silurian strata (Fig. 1) and is overlain disconformably by the Cedar Valley Group over its regional extent in Iowa, western Illinois, northern Missouri, and southeastern Minnesota. Its edge is overlapped by Cedar Valley strata to the west and south. The Wapsipinicon Group reaches thicknesses of up to 60 m south of the type area adjacent to the Plum River Fault Zone (Fig. 4), and is dominated by carbonate rock, but gypsum and anhydrite are significant components in southern and central Iowa (Fig. 4). The group encompasses two major T-R depositional cycles.

Cedar Valley Group

Owen (1852) termed the Middle Devonian carbonate sequence of eastern Iowa the "limestones of Cedar Valley," and McGee (1891) formally designated this interval the "Cedar Valley limestone." Subsequent definition of the Wapsipinicon Formation restricted the Cedar Valley Limestone to the interval above the Wapsipinicon and below the Upper Devonian shales of the Sweetland Creek and Lime Creek formations. The Cedar Valley was elevated to group status (Witzke *et al*., 1988) to include four formations, each corresponding to a major T-R cycle of deposition, and each separated from adjacent formations by an erosional unconformity or discontinuity surface. The constituent formations are, in ascending order, the Little Cedar, Coralville, Lithograph City, and Shell Rock (Fig. 3).

No type locality for the Cedar Valley Limestone was ever designated, but a primary reference section at Conklin Quarry near Iowa City has been proposed (Bunker *et al*., 1985). Where overlain by the Sweetland Creek or Lime Creek formations, the Cedar Valley Group varies considerably in thickness, ranging from 23 to 40 m in southeastern Iowa and reaching maximum thicknesses of 80 to 120 m in northern and central Iowa. The Cedar Valley Group disconformably overlies the Wapsipinicon Group over much of its extent, but Cedar Valley strata overlap the Wapsipinicon edge to the south and west to overstep Ordovician or Silurian rocks in parts of northern Missouri, northern Illinois (Collinson and Atherton, 1975), and western Iowa (Figs. 1, 5). The Cedar Valley Group is dominated by fossiliferous limestone in southeastern Iowa and northern Illinois, by dolomite and limestone in northern Iowa, and by dolomite and anhydrite in central Iowa.

Little Cedar Formation

The Little Cedar Formation (Fig. 3) includes lower Cedar Valley strata which are bounded below by the Wapsipinicon Group (or Ordovician-Silurian rocks where the Wapsipinicon is absent) and above by the Coralville Formation. The type locality is at the Chickasaw Park Quarry (Witzke *et al*., 1988) adjacent to the Little Cedar River in southwestern Chickasaw County, Iowa; this locality exposes one of the most complete sections (17 m) of the formation in northern Iowa. The Little Cedar Formation ranges from 15 to 37 m in thickness; it is thinnest in southeastern Iowa and thickest in northern and central Iowa. The Coralville overlies a disconformity or discontinuity surface at the top of the Little Cedar Formation at most localities. However, the Lithograph City Formation is locally incised into the Little Cedar Formation in parts of Johnson County and the Sweetland Creek Shale overlies the formation at a few

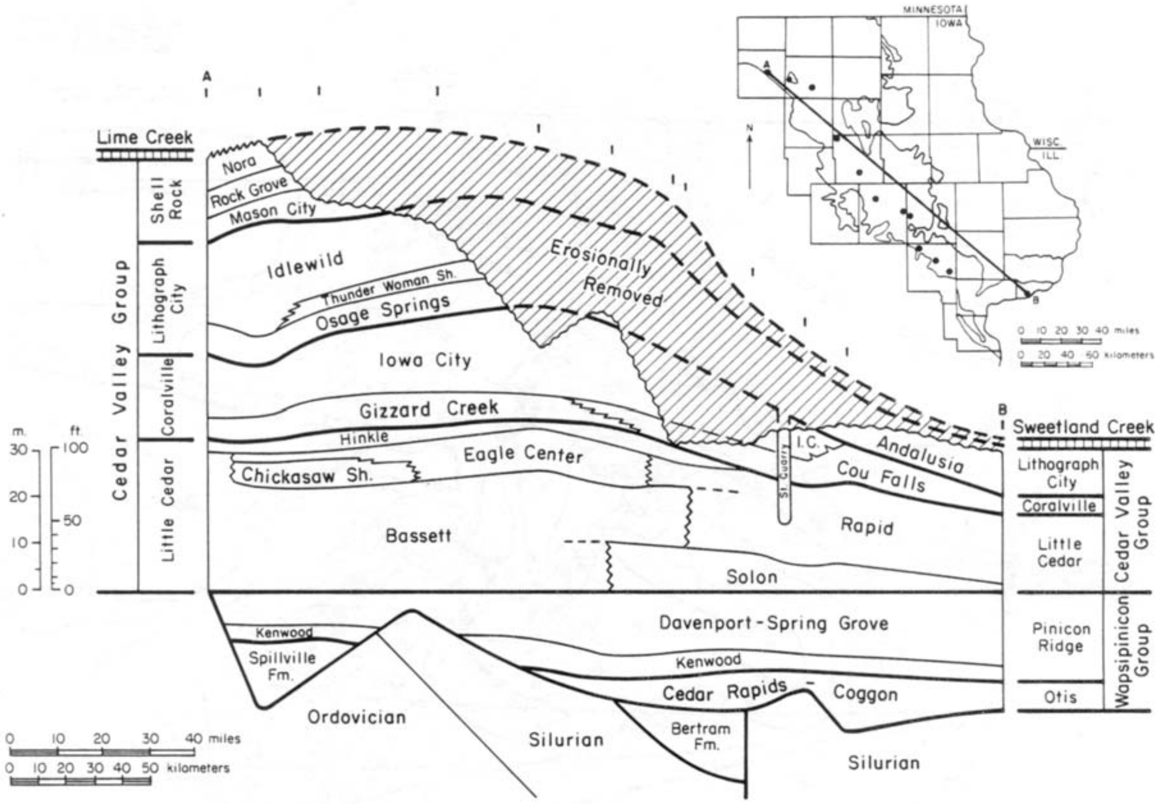


Figure 3. Generalized stratigraphic cross-section from north-central to extreme east-central Iowa, showing interpreted stratigraphic relationships of the various units of the Wapsipinicon and Cedar Valley groups (from Witzke *et al*., 1988).

few localities in southeastern Iowa. The Little Cedar Formation is interpreted to have been deposited during a large-scale T-R cycle (part of cycle IIa of Johnson *et al*., 1985), the Taghanic Onlap (Johnson, 1970). The formation is subdivided into three to four members in northern and central Iowa (in ascending order, Bassett, Chickasaw Shale, Eagle Center, and Hinkle) and two members in southeastern Iowa (Solon and Rapid). Subsequent discussion of the constituent members defines lithologic variations within the formation.

Solon Member. The Solon Member (Fig. 3) is dominated by fine skeletal muddy calcarenite (biomicrite and some biosparite) with scattered shaly or carbonaceous partings (Kettenbrink, 1973). Argillaceous calcilutite is present, especially near the northern limits of the member. Hardgrounds are developed locally. A thin sandy limestone is commonly present at the base; this sandy interval locally includes sandstone facies (Hoing Sandstone) in parts of northern Missouri and western Illinois (Collinson and Atherton, 1975; Tissue, 1977). The basal contact is disconformable, but the upper contact with the Rapid Member is variably gradational or sharp (locally a burrowed discontinuity surface or hardground). The Solon Member is limited geographically to areas of east-central and southeastern Iowa and adjacent areas of northern Missouri and Illinois. The member varies from 1.5 to 12 m in thickness and is thinnest to the southeast. It generally thickens to the north, and skeletal calcarenites of the Solon are replaced by argillaceous dolomites of the lower Bassett Member in that direction.

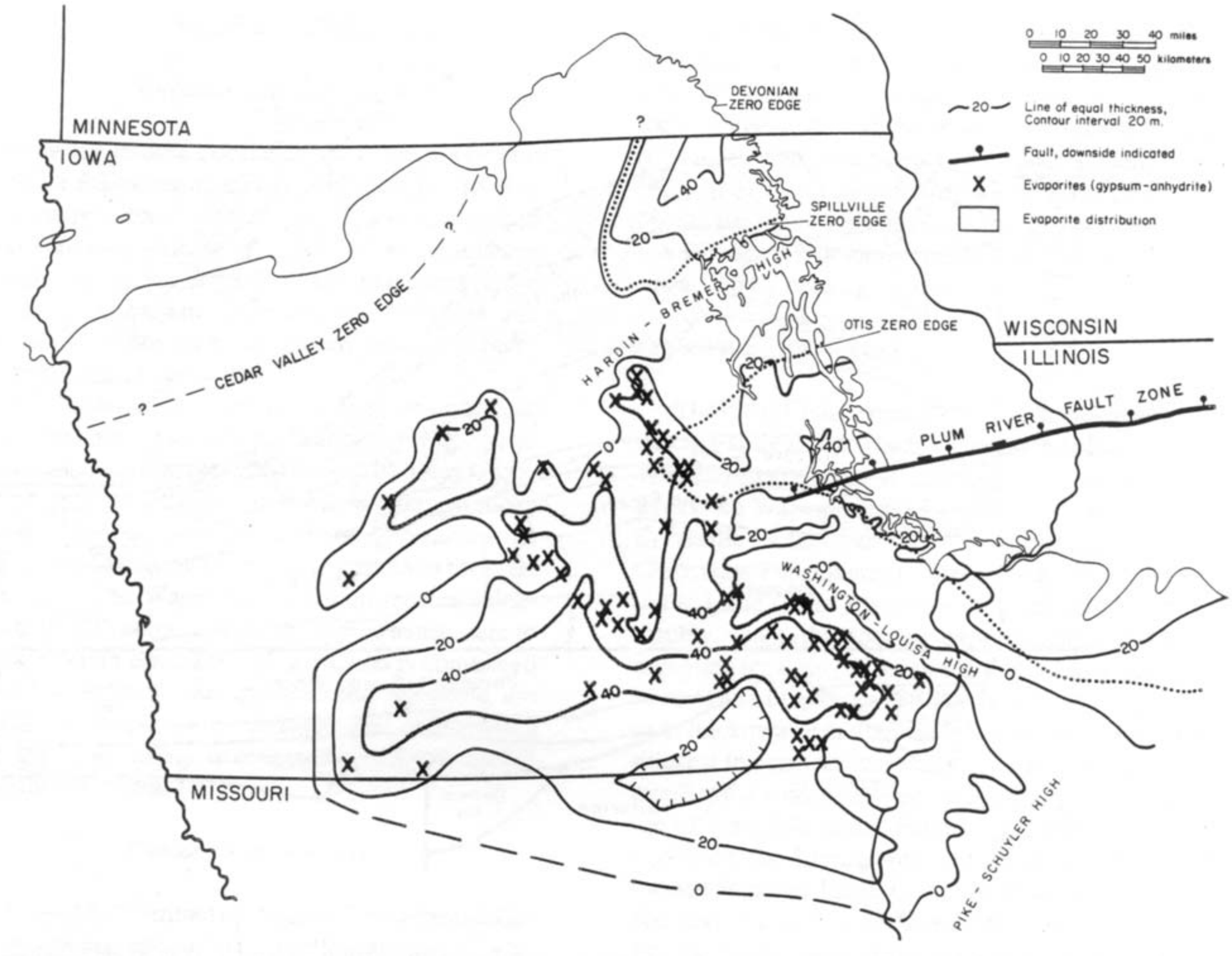


Figure 4. Isopach and evaporate distribution map of the Wapsipinicon Group (from Witzke *et al*., 1988).

Conodont faunas of the Solon span the upper Middle varcus through Lower hermanni (redefined by Klapper & Johnson, 1990) subzones (Bunker and Klapper, 1984; Witzke *et al*., 1985, 1988). The macrofauna of the Solon is abundant and diverse including brachiopods (Stainbrook, 1941a; Day, this guidebook), and corals and stromatoporoids (Stainbrook, 1941a; Mitchell, 1977), whose stratigraphic significance are described in further detail in Witzke *et al*. (1988).

Rapid Member. The Rapid Member (Fig. 3) is dominated by argillaceous calcilutite (ranging from micrite to sparse biomicrite), but shaly partings and lenses of calcarenite interbed with the sequence. The Rapid is divided into three widely recognizable descriptive lithologic units: 1) a lower fossiliferous calcilutite interval (some calcarenite) with common shaly partings ("bellula zone" of Stainbrook, 1941a); 2) a middle unit ("Pentamerella beds" of Stainbrook, 1941a) composed of interbedded fossiliferous calcilutite (some calcarenite) and unfossiliferous to sparsely fossiliferous burrowed calcilutite; this unit is capped by two widespread coralline biostromes (Zawistowski, 1971) and locally includes concentrations of glauconite and apatite pellets in some beds; and 3) an upper unit ("waterlooensis zone" of Stainbrook, 1941a) of fossiliferous calcilutite interbedded with lenses of echinoderm-rich calcarenite (packstones and

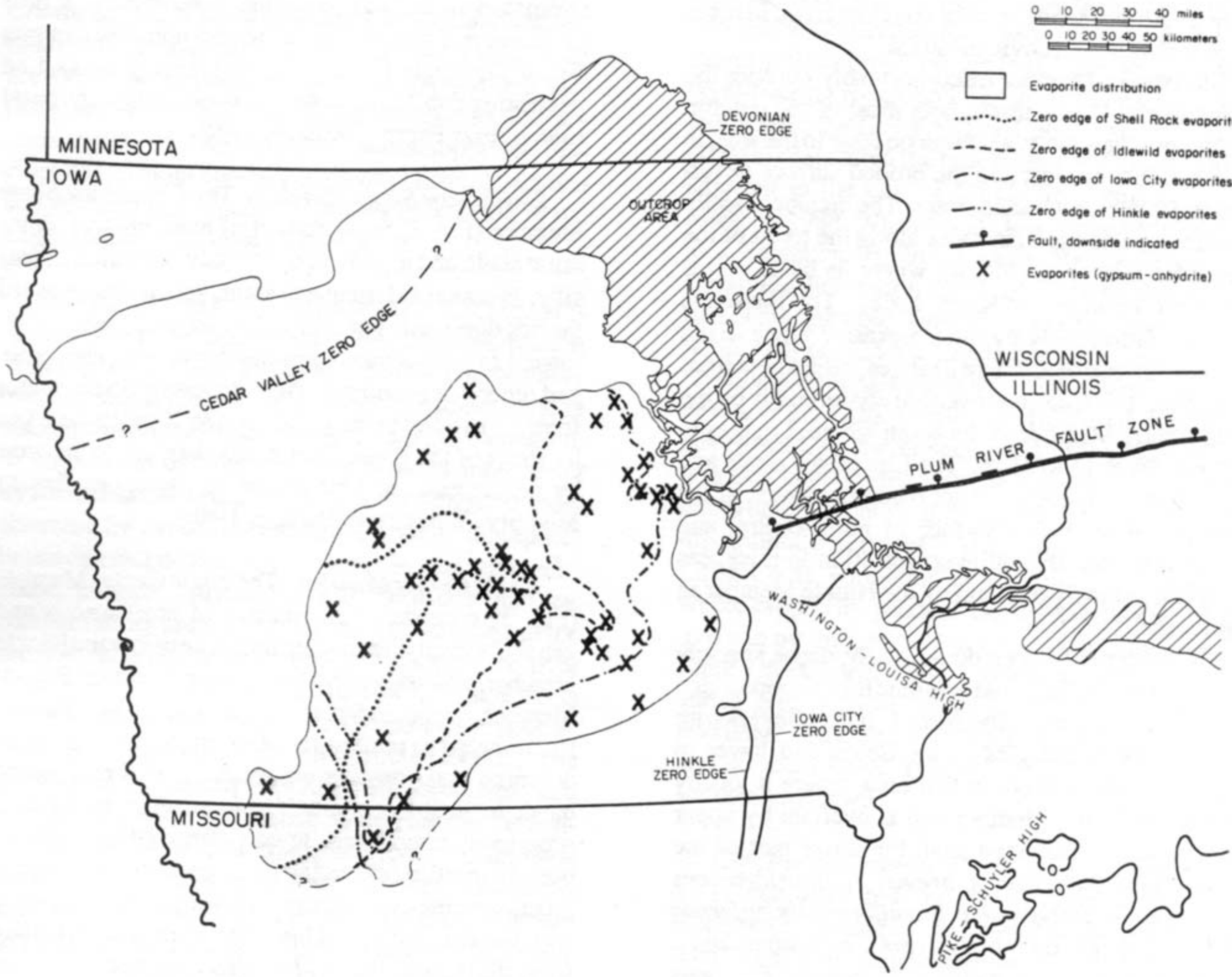


Figure 5. Evaporite distribution map of the Cedar Valley Group and the zero-edges of the Hinkle and Iowa City members (from Witzke *et al*., 1988).

grainstones to the north). The upper unit is glauconitic (in the lower half) in the type Rapid area, and is commonly cherty with prominent hardgrounds. The upper Rapid displays a greater degree of thickness and facies variations than is noted in the lower and middle strata; it varies in thickness from about 2 m in the south to 5 m in the north.

The Rapid Member conformably overlies the Solon, but its upper surface is marked by a widespread burrowed discontinuity surface over most of its geographic extent. It is sharply overlain by calcarenites of the Coralville Formation except near its northern limits where it is conformably overlain by the Hinkle Member (Fig. 3). The State Quarry Member of the Lithograph City Formation is locally incised into the Rapid in the type area, and the Sweetland Creek Shale overlies the Rapid at a few localities in the subsurface of extreme southeastern Iowa. The Rapid Member is recognized across southeastern and east-central Iowa and adjacent areas of western Illinois and northeastern Missouri. It is relatively uniform in lithology and thickness over its geographic extent, ranging in thickness from 13.5 to 18 m. The Rapid Member is replaced north of Palo by strata of the middle and upper Bassett, Chickasaw Shale, Eagle Center, and Hinkle members. The Solon and Rapid members are replaced southward in western Illinois and northern Missouri by skeletal calcarenites equivalent to part of the Callaway Formation.

Conodonts from the "bellula zone" span parts of the Lower and Upper hermanni subzones (Witzke *et al*., 1988). The lower Rapid ("bellula zone") contains a diverse brachiopod-dominated fauna which is described in detail by Stainbrook (1938a-1943b), Witzke *et al*. (1985), and Day (this guidebook). The upper part of the middle Rapid, by contrast, is an abundantly fossiliferous calcilutite to calcarenite containing conspicuous coralline biostromes over much of the geographic extent of the member. Conodonts of the subterminus Fauna, a probable equivalent of the disparilis Zone, first occur within this coralline interval (Witzke *et al*., 1985). Conodonts from the upper Rapid ("waterlooensis zone") are assigned to the Lower subterminus Fauna (Witzke *et al*., 1985). The upper Rapid is characterized by crinoidal and bryozoan-rich calcilutites and calcarenites. A relatively diverse brachiopod fauna is present and is described in detail by Stainbrook (1938a-1943b), and Day (this guidebook). Articulated specimens of camerate, inadunate, and flexible crinoids, blastoids, rhombiferans (Strobilocystites), starfish, edrioasteroids, and echinoids are known (Calhoun, 1983; Strimple, 1970).

Bassett Member. The Bassett Member (Fig. 3) is dominated by slightly argillaceous to argillaceous dolomite, commonly vuggy, and containing scattered to abundant fossil molds. Limestones and dolomitic limestones generally increase in abundance throughout the member southward in the Iowa outcrop belt. Chert nodules occur locally, generally in the upper half. Stylolites and hardgrounds are present, especially in the lower half of the member. The basal Bassett Member is silty, sandy, and/or conglomeratic in areas where it overlies Ordovician strata.

The Bassett Member disconformably overlies the Wapsipinicon Group throughout most of the outcrop belt, but overlaps the Wapsipinicon edge to the west in the subsurface to overstep the eroded surface developed on Upper Ordovician strata. The member locally overlies beveled Silurian rocks along the trend of the Hardin-Bremer High (Fig. 4), where its basal unit is coralline (Dorheim and Koch, 1962). The Bassett is overlain conformably by the Chickasaw Shale in the northern outcrop belt, where it ranges in thickness from 19 to 25 m. The Bassett is overlain conformably by the Eagle Center Member to the south where it ranges in thickness from 15 to 25 m. The Chickasaw Shale and Eagle Center members are not recognized west of the outcrop belt in the subsurface of north-central and central Iowa; the Bassett averages 30 m in thickness and is conformably overlain by the Hinkle Member in those areas.

The Bassett Member is dominated by dense, sparsely fossiliferous calcilutite and coralline to brachiopod-rich calcarenites near its southern limit. It interfingers with characteristic lithologies of the Solon and lower to middle Rapid members in that area, where it locally overlies the Solon Member and is overlain by upper Rapid strata. Conodonts from the lower part of the Bassett include Icriodus brevis, I. latericrescens latericrescens, Polygnathus linguiformis linguiformis (gamma and epsilon morphotypes), P. ovatinodosus, P. alveoliposticus, P. ansatus, P. varcus, P. xylus xylus, and others (Klug, 1982b; Klapper and Barrick, 1983; Witzke *et al*., 1988; Rogers, 1990). This fauna indicates assignment to the Middle varcus Subzone, and suggests correlation with most or all of the Solon Member to the south. The lower unit contains an abundant brachiopod fauna, typically atrypid-dominated (Independatrypa and Spinatrypa). Conodonts of the middle and upper intervals of the Bassett Member are not zonally significant but include I. brevis, I. latericrescens latericrescens, P. xylus xylus, and P. ovatinodosus (middle unit); stratigraphic position suggests correlation with the lower and middle parts of the Rapid Member. The middle part of the Bassett is typified by sparsely fossiliferous burrowed calcilutite fabrics, but fossiliferous beds occur within the unit. This unit also includes local packstone beds of Rensselandia and sparse corals (pachyporids and favositids) near the southern limits of the member. The upper part contains biostromal beds rich in corals and/or stromatoporoids, variably dominated by favositids, solitary rugosans, Hexagonaria, or domal or laminar stromatoporoids, and including Asterobillingsa near its southern limit. Glauconitic and phosphatic strata below the Eagle Center Member have produced an interesting fish fauna, as well as conodonts of the basal subterminus Fauna (Denison, 1985).

Chickasaw Shale Member. The Chickasaw Shale Member (Fig. 3) is composed of medium-gray dolomitic shale and argillaceous to shaly dolomite, in part silty. Nonskeletal, sparse to abundant burrow-mottled fabrics dominate, but skeletal material is noted in the lower 1 to 1.8 m at most localities (bryozoans, Neatrypa, and other brachiopods). The Chickasaw Shale ranges from 5.4 to 6.5 m in thickness. It is replaced to the south by strata of the Eagle Center Member and to the west by argillaceous and silty beds in the upper Bassett Member (Witzke and Bunker, 1984).

Eagle Center Member. The Eagle Center Member (Fig. 3) consists of an interval of argillaceous and generally cherty, laminated dolomite below the Hinkle Member and above the Chickasaw Shale or Bassett Member. The member is dominated by sparsely fossiliferous to unfossiliferous burrowed argillaceous dolomite and contains prominent chert nodules and bands in the lower one-half to seven-eighths. Faint to prominent laminations, in part disrupted by scattered burrow mottles, characterize much of the member at most sections; some laminations are pyritic (Anderson and Garvin, 1984). Thin dolomitized or silicified fossiliferous calcilutite and calcarenite beds are interspersed locally within the generally unfossiliferous sequence. The Eagle Center is not dolomitized to the southeast of the type area, where it is dominated by sparsely fossiliferous to unfossiliferous, burrowed, cherty, argillaceous calcilutite, in part laminated, and contains thin skeletal calcarenite beds. Upward it becomes dominantly finely calcarenitic. Upper Eagle Center strata, primarily in areas where the member overlies the Chickasaw Shale, contain stromatoporoids or corals and are locally biostromal. The Eagle Center Member ranges in thickness from 8 to 11 m where it overlies the Bassett Member, and is 1.4 to 4.2 m thick where it overlies the Chickasaw Shale.

Conodonts from the Eagle Center Member (Icriodus subterminus and Polygnathus xylus xylus) are assigned to the Lower subterminus Fauna (Witzke *et al*., 1988; Rogers,1990). Macrofauna is sparse in the member, but scattered fish debris (placoderm and shark) is noted in the laminated dolomites. Thin fossiliferous beds within the laminated sequence have yielded brachiopods (Neatrypa waterlooensis, Orthospirifer, Cranaena, and “Cupularostrum”), bryozoans, and crinoid debris (Anderson and Garvin, 1984). Upper strata are locally biostromal, primarily in the northern sections, and have yielded corals (Hexagonaria, solitary rugosans, and favositids), domal stromatoporoids, brachiopods, crinoid debris, and rostroconchs. The fauna and stratigraphic position indicates correlation of the Eagle Center with upper Rapid strata.

Hinkle Member. The Hinkle Member (Fig. 3) is the uppermost member of the Little Cedar Formation in northern and central Iowa, where it conformably overlies the Eagle Center or Bassett members and is disconformably overlain by the Coralville Formation. It conformably overlies the upper Rapid Member along its southernmost extent. The Hinkle Member is characterized by dense unfossiliferous “sublithographic” limestone and dolomitic limestone, in part with laminated, pelletal, intraclastic, and “birdseye” fabrics. Similar fabrics are noted at all known sections, but the member is partially to completely dolomitized over most of north-central and central Iowa. Hinkle strata are generally unfossiliferous, but burrows, ostracodes, and sparse brachiopods have been noted locally. The member is commonly fractured to brecciated, and argillaceous beds and minor shale (locally carbonaceous) are present at many sections. Laminated carbonates are petroliferous in part, and desiccation cracks and minor erosional disconformities occur within some Hinkle sequences. Gypsum molds are present locally (e.g., Klug, 1982b, p. 47), and the member includes extensive evaporites (gypsum and anhydrite) in central Iowa (Fig. 5). The Hinkle changes character near its eastern margin where faintly laminated limestones are interbedded locally with thin fossiliferous limestone beds containing brachiopods, echinoderm debris, favositids, and domal stromatoporoids. The Hinkle Member averages about 2.5 m in thickness and is known to vary between 0.4 and 4.1 m. Erosional relief, locally to 1 m, is evident below the Coralville Formation at some localities.

Coralville Formation

In an 1866 lecture at the University of Iowa, the internationally famous geologist Louis Agassiz emphasized the significance of fossil coral accumulations in the Iowa City area. Several months later, abundant corals were encountered in limestone layers during the construction of a mill along the Iowa River west of Iowa City. The State Press (December 19, 1866) gave an account of this and of the subsequent naming of a new town, Coralville, for these coral accumulations. Keyes (1912) proposed the term Coralville for these coral-bearing rocks, and included it as a stratigraphic unit within the Cedar Valley Limestone. Stainbrook (1941a) designated the type section at Conklin Quarry adjacent to the city of Coralville, Johnson County, Iowa. In 1988, Witzke *et al*. designated the Coralville as a formation within the Cedar Valley Group. The Coralville Formation includes a lower fossiliferous carbonate member with an abundant marine fauna (Cou Falls or Gizzard Creek members) and an upper carbonate-dominated unit with laminated, brecciated, or evaporitic textures and some restricted-marine faunas (Iowa City Member). The Coralville Formation was deposited during a single T-R depositional cycle and is bounded above and below by disconformities or discontinuity surfaces. The formation overlies the Little Cedar Formation at all known localities, and where capped by younger Devonian strata is variably overlain by the Lithograph City, Sweetland Creek, or Lime Creek formations. The Coralville formation varies greatly in thickness across Iowa, reaching a maximum thickness of 20 to 25 m in areas of central and northern Iowa. It is as thin as 3.9 m in parts of southeastern Iowa.

Cou Falls Member. The Cou Falls Member (Fig. 3) is characterized by fossiliferous fine-grained calcarenite (primarily an abraded-grain packstone) with coral and stromatoporoid biostromes through much of the sequence (Kettenbrink, 1973). Thin shaly and dark carbonaceous partings occur in the lower half. The Cou Falls Member sharply overlies a prominent discontinuity surface at the top of the Rapid Member; calcarenites of the Cou Falls infill vertical burrows along this surface which locally penetrate up to 30 cm into upper Rapid strata. The Cou Falls Member is conformably overlain by the Iowa City Member in the type area. The Cou Falls Member encompasses the entire Coralville Formation east of the Iowa City Member edge (Fig. 3), where it contains calcarenites (generally coralline) in the lower part and argillaceous calcilutite to calcarenite in the upper part. The Andalusia Member of the Lithograph City Formation overlies a discontinuity surface at the top of the Cou Falls Member in parts of southeastern Iowa. The Cou Falls Member is replaced to the north and west by the Gizzard Creek Member and locally overlies Gizzard Creek strata in a transitional belt near its northern limits. The Cou Falls disconformably overlies the Hinkle Member of the Little Cedar Formation along the southern margin of that unit. The Cou Falls Member ranges from 5 to 7 m in thickness in the type area, and varies between about 3.5 and 11 m in thickness over its geographic extent.

Conodonts of the Cou Falls Member are sparse, but include Icriodus subterminus, Mehlina gradata, Polygnathus angustidiscus and other undescribed species of Polygnathus; these indicate assignment to the Upper subterminus Fauna (Witzke *et al*., 1985; Rogers, 1990). Stainbrook (1941a) and Kettenbrink (1973) subdivided the lower Coralville sequence in Johnson County (Cou Falls Member) into two faunal intervals, the lower "Cranaena zone" and the upper "Idiostroma beds." The "Cranaena zone" contains prominent coralline biostromes dominated by colonial (Hexagonaria) and solitary rugosans (Pitrat, 1962), favositids, and massive stromatoporoids. Brachiopods are common in some beds (Day, 1988 & this guidebook). The "Idiostroma beds" are characterized by biostromal strata containing branching ("Idiostroma") and massive stromatoporoids, colonial (Hexagonaria) and solitary rugosans, and favositids. The Cou Falls Member east of the Iowa City edge (Figs. 3, 5) resembles "Cranaena zone" strata in the lower part, but includes argillaceous calcilutites and calcarenites in the upper part with brachiopods and crinoid debris, locally with corals, stromatoporoids, or abundant bryozoans (Klug, 1982a; Witzke *et al*., 1985; Day, 1988 & this guidebook).

Gizzard Creek Member. The Gizzard Creek Member (Fig. 3) is dominated by dolomite, generally medium- to thick-bedded in the lower part and medium- to thin-bedded in the upper part, but dolomitic limestones and calcite-cemented (poikilotopic sparites) dolomites are present. The Gizzard Creek Member is slightly argillaceous in part, and calcite-filled vugs are common. Intraclasts are present locally in some beds. The member contains scattered to abundant fossil molds, locally with calcitic fossils, and displays wackestone (calcilutite) to rare packstone fabrics, in part burrow mottled. The Gizzard Creek Member disconformably overlies the Hinkle Member at all localities, and is conformably overlain by the Iowa City Member at most localities. The Gizzard Creek Member ranges from 3.7 to 7 m in thickness.

Conodonts of the Gizzard Creek Member include Icriodus subterminus, Mehlina gradata, and Polygnathus angustidiscus (Witzke *et al*., 1988; Rogers, 1990) which are assigned to the Upper subterminus Fauna. Faunas of the Gizzard Creek are generally of low diversity and are characterized by sparse to abundant crinoid debris and brachiopods (Independatrypa, Athyris, and rare Tecnocyrtina; Day, 1988 & this guidebook). Rare gastropods and bryozoans have been noted, and branching stromatoporoids and favositids are present locally near the southern limits of the member in the outcrop belt.

Iowa City Member. The Iowa City Member (Fig. 3) is characterized by a diverse assemblage of lithologies that commonly share significant lateral facies variations over short distances. The member in the type area of central Johnson County includes the following lithologies: 1) laminated and pelleted calcilutites, commonly "sublithographic" with "birdseye" voids and stylolites; 2) pelleted calcilutites with scattered to abundant corals and/or stromatoporoids; 3) intraclastic, brecciated, or oncolitic limestones; and 4) some thin shales, in part carbonaceous (Kettenbrink, 1973; Witzke, 1984). Mudcracks and vadose pisoliths are noted in some beds, and erosional surfaces occur locally within the sequence (Witzke, 1984).

The Iowa City Member in the northern outcrop belt and in the subsurface of central Iowa is characterized by sedimentary fabrics similar to those of the type area, but includes dolomites and dolomitic limestones. There is a general increase in the relative abundance of shale, with shaly intervals locally up to 2 m thick, breccia, and intraclastic strata in this area, and some beds are locally sandy. Crystallotopic molds after sulfate evaporites have been identified locally. The thickest development of evaporites (gypsum and anhydrite) in the Cedar Valley Group occurs within the Iowa City Member of central Iowa. The Iowa City Member in the type area is disconformably overlain by the State Quarry Member of the Lithograph City Formation or by the Lime Creek Formation. The member is disconformably overlain by the Osage Springs Member of the Lithograph City Formation across northern and central Iowa. The Iowa City Member ranges from 0 to 8 m in thickness in the type area, and from 8 to 17 m across northern and central Iowa. The Iowa City Member is absent 12 km to the southeast of the type locality, where the entire Coralville Formation is represented by fossiliferous calcarenites of the Cou Falls Member. The edge of the Iowa City Member trends south-southwest from the type area (Fig. 5), and the member is absent in southeastern Iowa and adjacent parts of northeastern Missouri and western Illinois. Conodonts have not been recovered from the Iowa City Member. Laminated and "birdseye"-bearing strata are sparsely fossiliferous in part (stromatolites, calcareous algae, foraminifers, ostracodes and gastropods), and some calcilutites are burrow mottled.

Problems relating to the Coralville-Lithograph City contact

Fossiliferous calcilutites and some calcarenites interbed in the upper Iowa City Member sequence and contain low-diversity macrofaunas generally dominated by favositid corals and/or branching stromatoporoids (locally biostromal). A biostromal interval in the middle to upper part of the member ("Amphipora bed" of Kettenbrink, 1973) contains abundant branching stromatoporoids in the Johnson County type area, and this interval is presumed to correlate with stromatoporoid-rich strata to the north in the Garrison Quarry (Benton County, Iowa; STOP 1) area (Witzke *et al*., 1988). The recent recovery of the conodont Pandorinellina insita from laterally equivalent strata to "Amphipora" bearing beds at Garrison Quarry have tended to obfuscate the contact relationships between the Iowa City Member and the overlying Lithograph City Formation as originally defined by Bunker *et al*. (1986) and Witzke *et al*. (1988). At Garrison Quarry (STOP 1) P. insita bearing strata can be observed overlying and cross-cutting lower and middle Coralville Formation strata (Gizzard Creek and Iowa City members) which is similar to stratigraphic relationships observed between the State Quarry Member of the Lithograph City Formation and the underlying Coralville and Little Cedar formations in the Coralville Lake area north of Iowa City.

Watson (1974) proposed that the State Quarry Member was laterally equivalent to strata now included in the upper Iowa City Member. However, this proposal has not been supported by any physical evidence identified in subsequent studies. In particular, the locality along the west shoreline of Coralville Lake where Watson (1974) described facies relationships between the Coralville and State Quarry consists of a minor erosional re-entrant that cuts across critical sections which contain the calcilutite beds of both the

Coralville and State Quarry. Re-examination of the above described calcilutite beds within the "upper Coralville" indicates that these beds actually are contained within the upper part of the Cou Falls Member, and exhibit a lateral facies relationship with the Idiostroma beds. These calcilutite beds contain a brachiopod fauna that is distinctly associated with the Coralville Formation. Similarly, brachiopod faunas collected from the calcilutite beds of the State Quarry in this area are distinctively associated with the Lithograph City Formation (Jed Day, pers. comm., 1991) and not with the Coralville Formation.

Bunker *et al*. (1986) noted problems with the stratigraphic relationships between the Coralville and Lithograph City formations at Yokum Quarry in northwestern Blackhawk County, Iowa. In north-central Iowa, the basal contact of the Lithograph City Formation is primarily based upon the upward change in character from laminated lithographic and intraclastic unfossiliferous limestones from the underlying Coralville cycle below to fossiliferous limestones above. The overlying fossiliferous interval contains the conodont Pandorinellina insita and a brachiopod fauna characteristic of the Lithograph City Formation to the north. However, as noted by Bunker *et al*. (1986), the recovery of P. insita from the underlying laminated lithographic and intraclastic limestones at Yokum Quarry could suggest that the base of the Lithograph City should be moved downward. The inclusion of laminated lithographic and intraclastic limestones within the basal Osage Springs Member, however, is generally inconsistent with its character to the north and west, where it is a fossiliferous unit. Alternatively, the inclusion of these limestones with the Coralville Formation also poses a potential problem, since the first occurrence of P. insita would then fall within the upper regressive portion of the Coralville, instead of within the basal transgressive portion (Osage Springs-Andalusia) of the Lithograph City Formation as noted elsewhere in Iowa (ibid., p. 34).

The Amphipora beds at Garrison Quarry appear to equate with the initial Lithograph City marine transgression, as indicated by significant lateral incision of underlying Coralville units and by its contained faunas. By constrast, the Amphipora beds in Johnson County do not display lateral transition into open-marine facies, and lack faunas characteristic of the Lithograph City Formation (conodonts, brachiopods, etc.). As such, the Amphipora beds of the type Iowa City Member are interpreted to mark a minor transgressive event within the overall regressive phase of upper Coralville deposition. The significant Lithograph City marine transgression, initially marked by deposition of the State Quarry Member, in Johnson County, shows no obvious relationship to the Amphipora beds. Nevertheless, the absence of demonstrated litho- or biostratigraphic relationships between the Amphipora beds of the Iowa City Member and the State Quarry provides only negative evidence. The possibility that the Amphipora beds in Johnson County represent some early stage of Lithograph City transgression, correlative with similar facies at Garrison Quarry, cannot, as yet, be completely ruled out. Of special note is the fact, birdseye-bearing limestones in the lower type Iowa City Member are locally truncated and capped by an atrypid-bearing hardground surface and large stromatopotoid colonies below Amphipora bearing strata (Presidents House Quarry, Witzke, 1984). The vertical sequence resembles, in a gross sense, that seen above the Coralville Formation at Garrison Quarry.

The basal Lithograph City Formation across northern Iowa is marked by an open-marine carbonate, the Osage Springs Member, which is greater than 3 m thick. At Garrison Quarry, however, the basal marine interval of the interpreted Lithograph City Formation is locally less than 1 m thick, suggesting that this interval may not represent the Osage Springs transgression. Is Unit 27 (see STOP 1) at Garrison Quarry really the Osage Springs correlate? Does the basal insita-bearing interval at Garrison precede the Osage Springs transgression to the north? If so, the base of the Lithograph City Formation at Garrison Quarry (and presumbly correlative strata in an offshore direction, i.e. the State Quarry) would then correlate with strata currently placed in the upper Iowa City Member strata in northern Iowa. Does this mean that the Lithograph city transgression was step-wise, with the earliest transgressive phases not represented by marine incursion in the northern sections? It remains to be seen if there are any regional facies relationships between uppermost Coralville and lowermost Lithograph City strata. In general, the Coralville is disconformably overlain by Lithograph City strata at most Iowa localities, and the two formations are readily distinguishable by their stratigraphic position, depositional facies, and faunas. Nevertheless, if the lower Lithograph City transgression was a step-wise event, regional stratigraphic relations may need some minor revision. Further study is encouraged.

Lithograph City Formation

The Lithograph City Formation was proposed (Bunker *et al*., 1986; Witzke *et al*., 1988) for the interval lying disconformably between the Coralville Formation below and the Shell Rock Formation or Sweetland Creek Shale above. The type locality of the formation was designated in the old quarry area adjacent to the former town of Lithograph City, Floyd County, Iowa, where high quality stone for lithographic engraving was quarried in the early 1900s (see discussion and map in Bunker *et al*., 1986). The Lithograph City Formation in northern Iowa includes limestone, shale, and dolomite, variably fossiliferous, laminated, or brecciated; evaporites are present in central Iowa. The formation is dominated by fossiliferous limestone, dolomite, and shale in southeastern Iowa. Three members of the formation are recognized in northern Iowa (Osage Springs, Thunder Woman Shale, and Idlewild; Fig. 3). Two distinctive facies south of the northern outcrop belt are assigned member status within the Lithograph City Formation (Fig. 3; State Quarry Member in eastern Iowa and the Andalusia Member in southeastern Iowa and adjacent areas of northeastern Missouri and western Illinois). Where capped by younger Devonian strata, the formation ranges from about 20 to 36 m in thickness in northern and central Iowa. It is thinner to the southeast where it ranges from 0 to 12 m in thickness.

Significance of the insita Fauna. Klapper and Barrick (1978) recognized the difficulty of inferring habitat from observed distributions of conodonts in sedimentary rocks. However, they note that certain species characterize near-shore environments (e.g. Icriodus) while other species consistently occur in relative deeper offshore positions (e.g. Palmatolepis & Ancryodella). An excellent example of the contrast between the two biofacies is represented by the development of the insita biofacies, which is characterized by an improvished fauna of Pandorinellina insita and Icriodus sp. (Johnson & Sandberg, 1977). The insita Fauna as originally defined by Klapper *et al*. (1971) consisted of the interval of strata dominated by P. insita below strata containing the lowest occurrence of Ancyrodella rotundiloba. The lower limit of the insita Fauna has biostratigraphic significance, but its upper limit is not well defined; noted to range as high as the Middle asymmetrica Zone (Montagne Noire Zone 5, Klapper, 1988) in the Waterways Formation of Alberta (Uyeno, 1974). Strata with the first occurrence of Skeletognathus norrisi (Uyeno,1967) occupy a prominent stratigraphic position above the disparilis Zone and below the first occurrence of Ancyrodella rotundiloba (Johnson, 1978). This interval has commonly been correlated with the Lowermost asymmetrica Zone, originally defined on the range of Mesotaxis asymmetrica below the lowest occurrence of A. rotundiloba early form (Ziegler, 1971). Klapper and Johnson (1990) redefined this interval, terming it the norrisi Zone based upon the lowest occurrence of S. norrisi. The oldest part of the insita Fauna, characterized by an association of Pandorinellina insita and Skeletognathus norris,i is assigned to the norrisi Zone.

Osage Springs Member. The Osage Springs Member (Fig. 3) is characterized by fossiliferous dolomite and dolomitic limestone, in part slightly argillaceous, in the type area. Calcite-filled vugs and stylolites are common, and poikilotopic calcite cements are present locally in the upper part of the member. Thin intervals containing faintly laminated to intraclastic fabrics have been noted at some localities. The Osage Springs Member in its type area of north-central Iowa is similar both in thickness and lithology to the Gizzard Creek Member of the Coralville Formation, but is distinguishable by its higher stratigraphic position and differing fauna. The Osage Springs Member becomes limestone-dominated (skeletal calcilutite and calcarenite) southward in the northern Iowa outcrop belt, and stromatoporoids (locally biostromal) also become increasingly common in that direction. Fossiliferous and locally oolitic limestones and dolomites have been noted in central Iowa (Klug, 1982b). The member is conformably overlain by laminated carbonates of the Idlewild Member in the northern outcrop belt, and is conformably overlain by the Thunder Woman Shale in the southern outcrop belt and in the subsurface of central Iowa. The Osage Springs Member varies from 3.4 to 7.5 m in thickness.

The conodont Pandorinellina insita first occurs in north-central Iowa in the basal Osage Springs Member (Bunker *et al*., 1986). Based upon the first occurrence of P. insita within the basal Osage Springs Member, the Osage Springs has been correlated with the norrisi Zone (Witzke *et al*., 1985; Bunker *et al*., 1986; Witzke *et al*., 1988).

Macrofauna of the Osage Springs Member is dominated by brachiopods in northern outcrops; Allanella, Athyris, Independatrypa, and Strophodonta are characteristic (Day, 1988). Stromatoporoids become abundant to the south and include both massive and branching forms. Echinoderm debris is present in all sections, and bryozoans, gastropods, corals, and burrows have been noted locally.

Thunder Woman Shale Member. The Thunder Woman Shale Member (Fig. 3) is characterized by light to medium gray, slightly dolomitic and silty shale; argillaceous dolomite is present locally, in part laminated and with crystallotopic gypsum molds. Shelly fossils are absent in the member, but horizontal and subhorizontal burrow mottles are common in the upper half. Conodont fragments and fish debris have been noted in the subsurface of north-central Iowa (Klug, 1982b). The Thunder Woman Shale is present in the southern part of the northern outcrop belt of the Lithograph City Formation, and extends into the subsurface of central Iowa (Bunker *et al*., 1986). It is erosionally truncated to the south within the Devonian outcrop of eastern Iowa. The member is replaced northward in the outcrop belt of northernmost Iowa and adjacent Minnesota by carbonate dominated strata of the lower Idlewild Member (Fig. 3). The Thunder Woman Shale ranges from 3 to 6 m in thickness.

Idlewild Member. The Idlewild Member (Fig. 3) is characterized by an interbedded sequence of contrasting lithologic groupings: 1) laminated and pelleted lithographic and "sublithographic" limestones and their dolomitized equivalents, in part with mudcracks, "birdseye," or evaporite molds; 2) non-laminated dolomite and limestone, in part "sublithographic," pelleted, oncolitic, intraclastic, brecciated, and/or sandy, and locally containing mudcracks and "birdseye"; 3) calcareous shale, in part brecciated to intraclastic; and 4) fossiliferous dolomite and limestone (calcilutite and minor calcarenite), with scattered to abundant brachiopods and/or stromatoporoids (locally biostromal; see Smith & Stock this guidebook). Lithologic groupings 1 and 2 dominate the sequence at most localities, but group 4 lithologies are subequal in importance at some sections. Fossiliferous carbonates that interbed with the sequence cannot generally be correlated from section to section, although an interval of fossiliferous strata in the middle part of the member occurs at a similar stratigraphic position in most sections (lower "Unit D" of Witzke and Bunker, 1984, 1985) and probably correlates regionally. The Idlewild Member contains gypsum and anhydrite in the subsurface of central Iowa (Fig. 5), primarily in the lower part of the member. The member is replaced by fossiliferous carbonates of the middle and upper Andalusia Member in southeastern Iowa. Where capped by the Shell Rock Formation, the Idlewild Member ranges from 16 to 24 m in thickness.

Conodonts from fossiliferous beds in the Idlewild Member include Pandorinellina insita and Polygnathus angustidiscus; these are assigned to the insita Fauna, however, regional relations suggest that the member spans a portion of the range of the norrisi and Lower asymmetricus zones. Lithologic groupings 1 and 2 commonly contain ostracodes and are burrowed in part; stromatolites and gastropods have been noted locally. Fossiliferous beds in the member contain brachiopods (Day, 1988 & this guidebook); Allanella and Athyris typically dominate. Echinoderm debris is common in some beds, and bryozoans, gastropods, and ostracodes also occur. Stromatoporoids are abundant in some beds, and locally form biostromes (domal or branching forms variably dominate). Favositids are present locally.

State Quarry Member. The State Quarry Member (Fig. 3) is restricted to Johnson County, Iowa, where it occupies broad channels (1 to 1.5 km wide) incised into the Coralville and Little Cedar formations (to as low as the middle Rapid Member). It is covered by Quaternary sediments at most localities, but it is overlain locally by the Lime Creek Formation ("North Liberty beds"). The State Quarry Member is characterized by fossiliferous calcarenites and calcilutites (Watson, 1974). Skeletal calcarenites (packstones and abraded grainstones) predominate at most localities, and are crossbedded in part. These are dominated by echinoderm, brachiopod, and/or stromatoporoid grains. Intraclastic and pelletal calcarenites also occur. Skeletal calcilutites are present near the channel margins. Fish bone lags are noted locally at or near the base of the member. The State Quarry Member reaches thicknesses of up to 12 m.

The conodont fauna of the State Quarry Member includes Pandorinellina insita, Polygnathus angustidiscus, Skeletognathus norrisi, and Icriodus subterminus (Watson, 1974; Witzke *et al*., 1985; Kralick this guidebook); it is assigned to the norrisi Zone. Other conodonts are also present, many apparently reworked from Rapid and lower Coralville strata. The State Quarry Member contains a macrofauna characterized by abundant echinoderm debris, brachiopods, and stromatoporoids. A variety of brachiopods occur (Day, 1988 & this guidebook). Branching and massive stromatoporoids, solitary rugosans, favositids, auloporids, gastropods, nautiloids, spirorbids, ostracodes, trilobites, calcareous algae and foraminifera, and fish debris (placoderms and dipnoans) have been noted (Watson, 1974).

Andalusia Member. The Andalusia Member (Fig. 3) is characterized by argillaceous and fossiliferous dolomitic limestone, limestone, and dolomite with fossiliferous calcareous shales in the lower part. Dolomite content generally increases upward in the section. Coral and stromatoporoid biostromes are present in the upper two-third's of the member in its type area. Hardground and discontinuity surfaces, in part auloporid encrusted, occur within the Andalusia sequence in the lower and upper parts. The member overlies a discontinuity surface at the top of the Coralville Formation, and where capped by younger Devonian strata, is disconformably overlain by the Sweetland Creek Shale. The Andalusia Member is replaced by strata of the Osage Springs and Idlewild members to the northwest along the outcrop belt, and in subsurface sections it locally interfingers up depositional slope with the State Quarry Member in the basal part. The Andalusia Member, where capped by the Sweetland Creek Shale, ranges from about 6 to 12 m in thickness.

Conodonts of the insita Fauna range through most of the Andalusia Member and include Pandorinellina insita, Mehlina gradata, Icriodus subterminus, and Polygnathus sp. (Witzke *et al*., 1985; Day, this guidebook). Uppermost strata of the member have yielded Ancyrodella rugosa, A. africana, A. alata (late form), Mesotaxis asymmetricus, I. subterminus, and M. gradata; these forms indicate assignment to the upper part of the Lower asymmetricus Zone (ibid.; also correlated with M.N. Zone 3, Klapper, 1988; Johnson and Klapper, 1992). Brachiopods of the Andalusia Member have been described by Day (1988 & this guidebook). Echinoderm debris is common to abundant, and bryozoans, bivalves, gastropods, rostroconchs, nautiloids, and fish debris are noted in some beds. Biostromal units in the upper Andalusia Member are variably dominated by solitary rugosans (Tabulophyllum sp.) or massive stromatoporoids.

Shell Rock Formation

Belanski (1927) named the "Shellrock stage" (formation) for a limestone-dominated interval exposed along the Shell Rock River in northern Iowa, and subdivided it into three "substages" (members), in ascending order, the Mason City, Rock Grove, and Nora. The Shell Rock Formation is now included in the upper Cedar Valley Group (Witzke *et al*., 1988; Fig. 3). A comprehensive summary of the stratigraphy of the formation in the type area is given by Koch (1970) and Witzke *et al*. (1988). The Shell Rock Formation is characterized by fossiliferous carbonates with some shale in the type area, but incorporates laminated, "birdseye"-bearing, brecciated, and intraclastic facies in the western outcrop and subsurface. Where capped by younger Devonian strata, the Shell Rock Formation ranges from about 17 to 24 m in thickness over its known geographic extent in northern and central Iowa. It disconformably overlies the Idlewild Member, and erosional relief has been noted locally. The eroded upper surface of the formation is buried by the Lime Creek Formation.

Conodonts of the Shell Rock Formation, which include Ancyrodella gigas, Polygnathus asymmetricus, and others (Anderson, 1964, 1966; Witzke *et al*., 1988), indicate correlation with the Middle and/or Upper asymmetricus zones. Brachiopod faunas of the Shell Rock are correlated with Faunal Interval 30 (= Middle asymmetricus Zone) of the western United States by Day (1988). Brachiopods and echinoderm debris are present in all members, and articulated specimens of crinoids, rhombiferans, edrioasteroids, and disarticulated echinoids are known from the Mason City Member (Belanski, 1928; Koch and Strimple, 1968; Strimple, 1970). Molluscs are common locally and include bivalves, gastropods, nautiloids, and scaphopods. Biostromal beds in the Mason City and Nora members are dominated by stromatoporoids, and massive (tabular to subspherical) and branching forms are present (see taxonomic studies by Stock, 1982, 1984a, b). Corals (solitary and colonial rugosans, and tabulates) occur in some beds. Additional fossils include ostracodes, spirorbids, conularids, calcispheres, calcareous algae, charophytes, and fish debris (Koch, 1970).

"North Liberty Beds"

Approximately 1-1/2 miles to the northeast of North Liberty in a tributary (NE 1/4 sec. 7 to NW 1/4 sec. 8, T80N R6W) to the Iowa River there are a series of discontinuous exposures of a fine-grained, greenish-blue, noncalcareous shale. Discontinuous brown shales occur locally near the base, but exposures are poor and relationships to the green shale are unclear. Abundant spore carps are noted in these beds in well cuttings to the west. The "North Liberty beds" range in thickness from 0 to 75 feet, and variably overlie Coralville, State Quarry, and Andalusia (?) strata within the area. An argillaceous dolomitic unit occurs in the upper part in wells around North Liberty, and is tentatively assigned to the Cerro Gordo Member of the Lime Creek Formation (Cerro Gordo strata are exposed 16 mi to the west at Middle Amana). The recovery of Palmatolepis semichatovae (Müller & Müller, 1957, p. 1101-1102, Pl. 142, fig. 9; see synonymy in Klapper & Lane, 1988; Day, 1990) from the "North Liberty beds" provides a basis for correlation with the Juniper Hill to lower Cerro Gordo members of the Lime Creek Formation, north-central Iowa (Day, 1990). The lowest occurrence of P. semichatovae defines the base of Frasnian Zone 5 in the Alberta conodont sequence (Klapper & Lane, 1988), and suggests assignment of the "North Liberty beds" to this zone. Directly underlying the "North Liberty beds" is an undefined "dark yellow-brownish, dolomitic, fine crystalline thin-bedded limestone" (Müller & Müller, 1957; p. 1075). Müller and Müller (1957) considered the possibility that this dolomitic unit could represent "basal State Quarry limestone," or uppermost Cedar Valley, as suggested by Youngquist (1947). Several samples were dissolved in acetic acid for conodonts by Müller and Müller, but with no success. This dolomitic unit is re-evaluated in view of the new stratigraphic framework. In traversing up the same tributary from its opening at Coralville Lake, a normal stratigraphic succession from basal Cou Falls through the Iowa City members is encountered, with occasional outcrops of State Quarry overlying various units of the Coralville. Along the upper reaches of the tributary is an exposure of this dolomitic unit in apparent vertical sequence above the Iowa City Member (same locality as the overlying "North Liberty beds" noted above). Based upon lithostratigraphic relationships as defined by Witzke *et al*. (1988), this unit is tentatively assigned to the Andalusia Member of the Lithograph City Formation. Approximately 3 kg of this unit were processed for conodonts, with Icriodus subterminus the only element recovered at this time. Of interest, uppermost State Quarry strata near the southern margin of the type State Quarry channel include dolomitic lithologies, perhaps suggesting that the State Quarry channel is gradationally capped by Andalusia dolomitic strata. Dolomitic strata apparently overstep the State Quarry margins to lie directly on upper Coralville strata (at North Liberty). An examination of the combined geologic and structure map of the Coralville Lake area (Plocher and Bunker, 1989, fig. 6) shows that the "North Liberty beds" and Lithograph City Formation are primarily contained within a northeast-southwest trending syncline developed along the southeastern flank of the Twin View Heights Anticline. Preservation of the State Quarry Limestone is fortuitous because it is preserved in a paleotopographic low cut into the Coralville and Little Cedar formations, and because of its structural preservation within a local syncline.

DEPOSITIONAL CYCLES

The Wapsipinicon and Cedar Valley groups display stratigraphic and biogeographic relations that are critical for understanding paleogeography and depositional systems in the Devonian seaways of the central North American midcontinent region. The first marine transgression into the area was marked by deposition of Otis and Spillville strata during the Late Eifelian. This transgression also apparently breached the Transcontinental Arch, establishing faunal communication between eastern and western regions of North America across shallow cratonic facies in the Iowa area. Subsequent deposition of the

Pinicon Ridge Formation marked a regional expansion of the seaway, but the expanded seaway apparently displayed restricted circulation patterns that excluded normal-marine benthos across the region. Antiestuarine circulation (Witzke, 1987) with circulatory restrictions to the east and northwest may have promoted the development of hypersalinity in the region, and extensive shallow-water and/or supratidal evaporites were deposited.

Midcontinent Carbonate Shelf

Subsequent deposition of the Cedar Valley Group was marked by significant expansion of the seaway, and open-marine facies spread across most of Iowa. Stratigraphic relationships within the Cedar Valley Group show a marked thinning of all formations into southeastern Iowa (Fig. 3). Although stratigraphic thinning is commonly associated with shallowing depositional trends in many basins, facies in southeastern Iowa are consistently deeper-water and more open-marine than those to the north and west. In fact, the shallower-water facies, including evaporites (Fig. 5), occupy the central region of the Iowa Basin (Fig. 2). Therefore, the Iowa Basin did not develop as a bathymetric basin, but represents an intershelf basin in which shallow-water and mudflat sedimentation kept pace with increased subsidence during deposition of the Cedar Valley Group (and Lime Creek Formation as well, Witzke, 1987). Tidal-flat facies did not prograde out of the intershelf basin area during regressive episodes, but terminated at an intracratonic shelf margin, which is preserved in southeastern Iowa and adjacent northeastern Missouri (Fig. 5, Hinkle and Iowa City edges). This shelf margin bounded an area to the west termed the "Midcontinent Shelf" (Fig. 6) by Slingerland (1986), who numerically modelled tidal effects in the Late Devonian epicontinental seaway. Tidal influence is evident by extensive intertidal and supratidal mudflat facies in the Midcontinent Carbonate Shelf area (i.e. the Iowa Basin area), and by tidal-channel facies (e.g. the State Quarry Member) along the intracratonic shelf margin.

The progressive deepening of depositional facies of the Cedar Valley Limestone to the southeast may relate to subsidence in the Illinois Basin, in a manner similar to that described for succeeding deposition of the Lime Creek Formation (Witzke, 1987). Sedimentation patterns in the Illinois Basin throughout the Devonian indicate consistently deeper-water depositional conditions than that interpreted for coeval strata in northern and central Iowa. However, a linear deepening trend between the Midcontinent Carbonate Shelf area and the deep Illinois Basin is not as evident during Cedar Valley deposition, primarily because of an intervening structural high in central Illinois, the Sangamon Arch (Whiting and Stevenson, 1965).

Cycle Boundaries

Deposition of the Wapsipinicon and Cedar Valley groups in Iowa was marked by a series of six major T-R depositional cycles (Figs. 3, 7). Each cycle of the Cedar Valley Group is bounded regionally by disconformities and each was terminated by the progradation of mudflat facies. Evaporite deposition generally occurred during the regressive portions of each cycle (Fig. 7). These cycles correspond closely to T-R cycles Ie through IIc of Johnson *et al*. (1985), and additional subcycles are recognized. T-R cycle IIa of Johnson *et al*. (1985) is provisionally subdivided into three subcycles in the Iowa area as shown on Figure 6. Additional minor T-R subcycles are interpreted for the following intervals: Kenwood, Spring Grove-Davenport, lower-middle Rapid, upper Rapid, upper Iowa City, middle-upper Idlewild, Mason City-lower Rock Grove, and upper Rock Grove-Nora.

A significant erosional hiatus (Upper asymmetricus and most or all of the A. triangularis zones) separates the Shell Rock and Lime Creek formations in Iowa (Figs. 3, 7), indicating complete withdrawal of Devonian seas from the Iowa area following Shell Rock deposition. If general southeastward thinning of stratigraphic units and depositional trends observed through most of the Cedar Valley sequence also hold for the Shell Rock Formation, a thin Shell Rock section would be expected to have been deposited in southeastern Iowa (Fig. 3). The apparent absence of Shell Rock strata in this area would be anomalous were it not for the development of a significant regional unconformity following Shell Rock deposition. It is suggested that Shell Rock strata in southeastern Iowa were removed by erosion rather than nondeposition. Lime Creek sediments ("Independence shale") locally infill karstic openings within

Middle Devonian carbonates of east-central Iowa, and an episode of pre-Lime Creek erosion and karstification has been interpreted (Bunker *et al*., 1985).

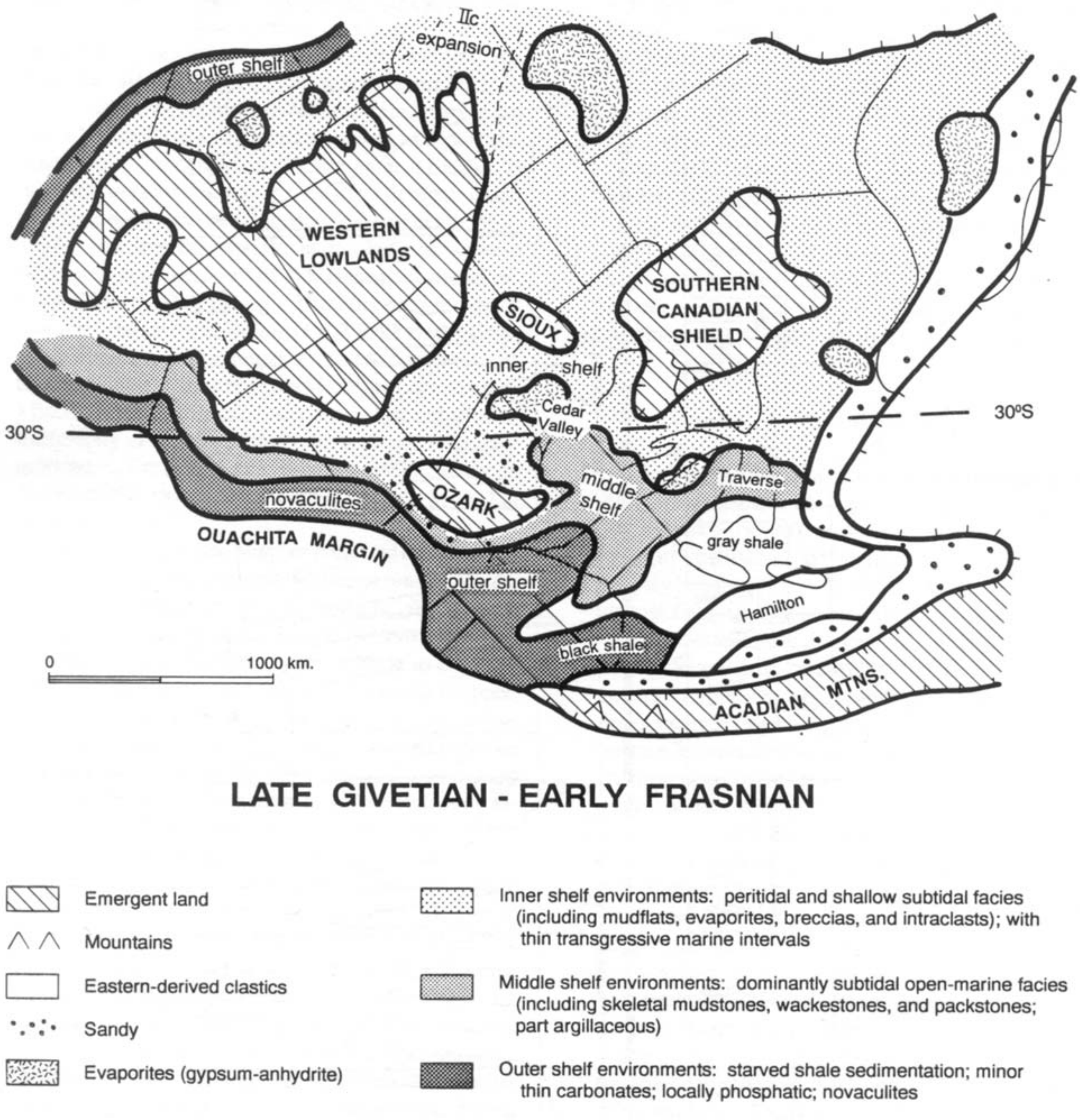


Figure 6. Paleogeographic map of the Midcontinent Carbonate Shelf area during Cedar Valley Deposition.

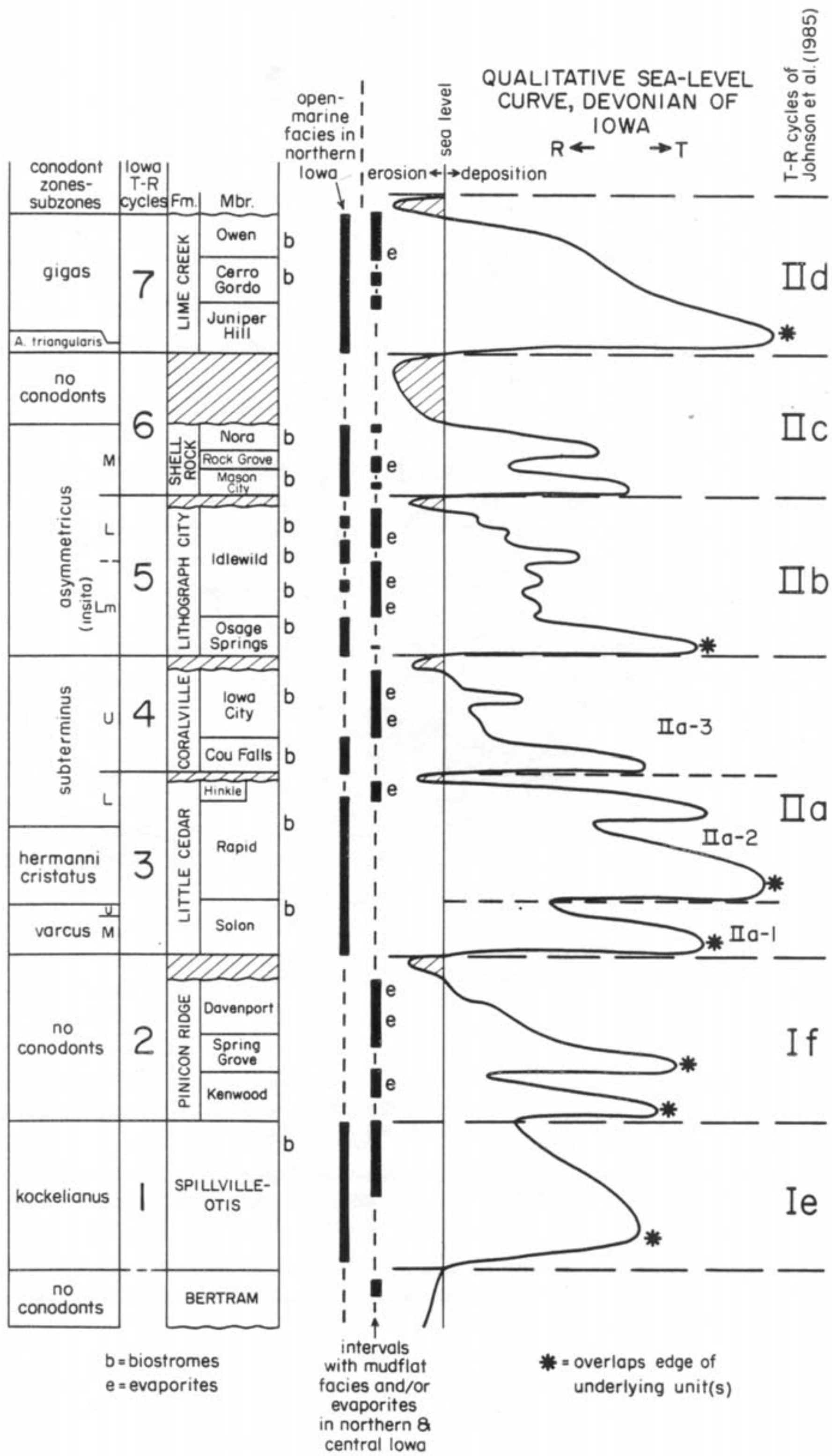


Figure 7. Qualitative sea-level curve for the late Middle and early Upper Devonian rocks of Iowa and their relationship to the T-R cycles of Johnson *et al*. (1985). (from Witzke *et al*., 1988).

INTERREGIONAL CORRELATIONS

While the lithostratigraphic framework of the Iowa Cedar Valley Group can be constructed upon the basic tenet of T-R cycles, extrapolation and correlation of these T-R cycles across the Midcontinent Carbonate Shelf area are in need of further study and refinement. A brief summary of proposed relationships between the Cedar Valley Group and strata in central Missouri and Manitoba is contained in Witzke *et al*. (1988). A lithostratigraphic framework for the Michigan Basin area has been in part developed by Kesling *et al*. (1974, 1976), and this framework, particularly in western Michigan, is reminiscent of T-R cycles defined in the Iowa Cedar Valley Group. The conodont biostratigraphic framework as defined by Witzke *et al*. (1988) and summarized in this report provides a potential basis for correlation into the western Michigan portion of the Midcontinent Carbonate Shelf area. Conodont biostratigraphy in the Michigan Basin area has been summarized by Orr (1971) and Bultynck (1976), although conodont ranges and zonal assignments are in need of re-examination.

In 1982, Ziegler and Klapper proposed the disparilis Zone, which is characterized by Klapperina disparilis, Klapperina disparata, and Klapperina disparalvea. Additionally, Klapper and Johnson (1990) proposed two subzones within the disparilis Zone to coincide with informal lower and upper parts (Ziegler & Klapper, 1982) based on the entry within the zone of Polygnathus dengleri (upper part). The recovery of Klapperina disparalvea by the authors from the basal exposure of the type Petoskey Formation therefore indicates assignment of the Petoskey to an age no older than the lower disparilis Zone. This is in opposition to assignment of the younger Thunder Bay and Whiskey Creek formations to the varcus Zone (Orr, 1971; Bultynck, 1976; Gutschick & Sandberg, 1991) and indicates that correlations within a significant portion of the Traverse Group of Michigan needs reassessment. Assuming that the insita Fauna of the Lithograph City Formation (as noted by the occurrence of S. norrisi within the State Quarry Member, Watson, 1974) correlates with the norrisi Zone, then the subjacent I. subterminus Fauna in the upper Little Cedar (above the Rapid biostromes) and Coralville formations must correlate with part or all of the disparili Zone. However, diagnostic species of the disparilis Zone, which developed in an offshore conodont biofacies, have not yet been noted in association with the nearshore I. subterminus Fauna of the Iowa portion of the Midcontinent Carbonate Shelf area.

The sequence of T-R cycles in western Michigan is reminiscent of that seen in Iowa, with fossiliferous subtidal marine intervals capped by regressive packages (like the Charlevoix amd parts of the Whiskey Creek) containing sublithographic limestones, oolites, exposure surfaces, and local evaporites. Consistent with occurrences of disparalis Zone conodonts in the Petoskey (this study) and Ancyrodella rotundiloba in the Jordan River (Bultynck, 1976, loc. 6c), the sequence of T-R cycles in the Traverse Group of western Michigan is tentatively related to the Cedar Valley Group as follows: 1) [upper] Gravel Point-Charlevoix and Little Cedar, 2) Petoskey and Coralville, 3) Whiskey Creek and lower Lithograph City, and 4) Jordan River-Squaw Bay (upper) and upper Lithograph City. Additional litho- and biostratigraphic studies are needed.

SUMMARY

Although some epicontinental sea bottoms apparently were characterized by uninterrupted gently sloping surfaces (ramps), some epicontinental seas, like those in which the Cedar Valley Group were deposited, display linear belts across which significant changes in depositional slope and sedimentary facies are noted. These belts delineate intracratonic shelf margins separating “inner” from “middle” or “outer” shelf environments. Exposures of Cedar Valley strata in eastern Iowa occur along the general transect of such shelf margin environments, with deeper (“middle” shelf) environments to the east and southeast. The basic T-R cycles of the Cedar Valley Group (Witzke *et al*., 1988) consist of a basal fossiliferous interval which records deposition in open-marine carbonate shelf environments during successive transgressive phases, while laminated, intraclastic, brecciated carbonates and evaporites record deposition in shallow, restricted subtidal and tidal-flat settings during the regressive (progradational) phase. The hierachial order of stratigraphic nomenclature within the Middle Devonian rocks of the Midcontinent Carbonate Shelf region is best developed within the framework of cyclic patterns of

deposition. The Wapsipinicon and Cedar Valley groups of the Midcontinent Carbonate Shelf region record repetitive patterns of deposition, which can be observed over large areas of the continental interior and correlated with apparent eustatic sea-level events elsewhere across Euramerica.

REFERENCES

Anderson, W.I., 1964, Upper Devonian and Lower Mississippian conodonts from north-central Iowa: unpublished Ph.D. dissertation, University of Iowa, 215 p.

Anderson, W.I., 1966, Upper Devonian conodonts and the Devonian-Mississippian boundary of north-central Iowa: Journal of Paleontology, v. 40, p. 395-415.

Anderson, W.I., and Garvin, P.L., 1984, The Cedar Valley Formation (Devonian), Black Hawk and Buchanan counties: carbonate facies and mineralization: Geological Society of Iowa, Guidebook No. 42, 47 p.

Belanski, C.H., 1927, The Shellrock Stage of the Devonian of Iowa: American Midland Naturalist, v. 10, p. 316-370.

Belanski, C.H., 1928, The Shellrock Stage of the Devonian of Iowa; Description of some typical fossils of the Shellrock Stage: American Midland Naturalist, v. 11, p. 165-212.

Bultynck, P.L., 1976, Comparative study of Middle Devonian conodonts from north Michigan (U.S.A.) and the Ardennes (Belgium-France): Geological Society of Canada, Special Paper no. 15, p. 119-141.

Bunker, B.J., and Klapper, G., 1984, Conodont zones and correlation of the Cedar Valley-State Quarry interval of eastern Iowa: Geological Society of Iowa, Guidebook No. 41, p. 15-18.

Bunker, B.J., Ludvigson, G.A., and Witzke, B.J., 1985, The Plum River Fault Zone and the structural and stratigraphic framework of eastern Iowa: Iowa Geological Survey, Technical Information Series No. 13, 126 p.

Bunker, B.J., Witzke, B.J., and Day, J.E., 1986, Upper Cedar Valley Stratigraphy, North-Central Iowa, Lithograph City Formation: Geological Society of Iowa, Guidebook No. 44, 41 p.

Bunker, B.J., Witzke, B.J., Watney, W.L., and Ludvigson, G.A., 1988, Phanerozoic history of the central midcontinent, United States: in Sloss, L.L. (ed.), Sedimentary Cover - North American Craton: U.S., Geological Society of America, The Geology of North America, v. D-2, p. 243-260.

Calhoun, S., 1983, Crinoids of the Devonian Cedar Valley Limestone in Iowa: unpublished M.S. thesis, University of Iowa, 153 p.

Collinson, C., and Atherton, E., 1975, Devonian System: Illinois State Geological Survey, Bulletin 95, p. 104-123.

Day, J., 1988, The brachiopod succession of the Late Givetian-Frasnian of Iowa: in McMillan, N.J., Embry, A.F., and Glass, D.J. (eds.), Devonian of the World, Canadian Society of Petroleum Geologists, Memoir 14, Volume III: Paleontology, Paleoecology, and Biostratigraphy, p. 303-325.

Day, J., 1990, The Upper Devonian (Frasnian) conodont sequence in the Lime Creek Formation of north-central Iowa and comparison with Lime Creek ammonoid, brachiopod, forminifer, and gastropod sequences: Journal of Paleontology, v. 64, p. 614-628.

Denison, R.H., 1985, A new ptyctodont, Ptyctodopsis, from the Middle Devonian of Iowa: Journal of Paleontology, v. 59, p. 511-522.

Dorheim, F.H., and Koch, D.L., 1962, Unusual exposure of Silurian-Devonian unconformity in Loomis Quarry near Denver: Proceedings of the Iowa Academy of Science, v. 69, p. 341-350.

Gutschick, R.C., and Sandberg, C.A., 1991, Upper Devonian biostratigraphy of Michigan Basin: Geological Society of America, Special Paper, 256, p. 155-179.

Johnson, J.G., 1970, Taghanic Onlap and the end of North American provinciality: Geological Society of America Bulletin, v. 81, p. 2077-2106.

Johnson, J.G., 1978, Devonian, Givetian age brachiopods and biostratigraphy, central Nevada: Geologica et Palaeontologica, v. 12, p. 117-150.

Johnson, J.G., and Klapper, G., 1992, North American midcontinent T-R cycles: Oklahoma Geological Survey Bulletin 145, p.

Johnson, J.G., Klapper, G., and Sandberg, C.A., 1985, Devonian eustatic fluctuations in Euramerica: Geological Society of America Bulletin, v. 96, p. 567-587.

Johnson, J.G., and Sandberg, C.A., 1977, Lower and Middle Devonian continental-shelf rocks of the western United States: in Murphy, M.A., Berry, W.B.N., and Sandberg, C.A. (eds.), Western North America Devonian, Riverside, California, University of California, Campus Museum Contribution 4, p. 121-143.

Kesling, R.V., Segall, R.T., and Sorensen, H. O., 1974, Devonian strata of Emmet and Charlevoix counties, Michigan: Museum of Paleontology, Papers on Paleontology, No. 7, 187 p.

Kesling, R.V., Johnson, A.M., and Sorensen, H.O., 1976, Devonian strata of the Afton-Onaway area, Michigan: Museum of Paleontology, Papers on Paleontology, No. 17, 148 p.

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

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

Klapper, G., 1988, The Montagne Noire Frasnian (Upper Devonian) conodont succession: in McMillan, N.J., Embry, A.F., and Glass, D.J. (eds.), Devonian of the World, Canadian Society of Petroleum Geologists, Memoir 14, Volume III: Paleontology, Paleoecology, and Biostratigraphy, p. 449-468.

Klapper, G., and Barrick, J.E., 1978, Conodont ecology; pelagic versus bentic: Lethaia, v. 11, p. 15-23.

Klapper, G., and Barrick, J.E., 1983, Middle Devonian (Eifelian) conodonts from the Spillville Formation of northern Iowa and southern Minnesota: Journal of Paleontology, v. 57, p. 1212-1243.

Klapper, G., and Johnson, J.G., 1990, Appendix 3. Revisions of Middle Devonian conodont zones: in Johnson, J.G., 1990, Lower and Middle Devonian brachiopod-dominated communities of Nevada, and their position in a biofacies-province-realm model: Journal of Paleontology, v. 64, p. 902-941 (p. 934-936).

Klapper, G., and Lane, H.R, 1988, Frasnian (upper Devonian) conondont sequence at Luscar Mountain and Mount Haultain, alberta Rocky Mountains: in McMillan, N.J., Embry, A.F., and Glass, D.F. (eds.), Devonian of the World, Canadian Society of Petroleum Geologists, Memoir 14, Volume III: Paleontology, Paleoecology and Biostratigraphy, p. 469-478.

Klapper, G., Sandberg, C.A., Collinson, C., Huddle, J.W., Orr, R.W., Richard, L.V., Schumacher, D., Seddon, G., and Uyeno, T.T., 1971, North American Devonian conodont biostratigraphy: Geological Society of America Memoir 127, p. 285-316.

Klug, C.R., 1982a, The subsurface Devonian lithostratigraphy of southeastern Iowa: Iowa Geological Survey, Open File Report 82-1, 33 p.

Klug, C.R., 1982b, Devonian stratigraphy and conodont biostratigraphy from portions of two cores in central Iowa: Iowa Geological Survey, Open-File Report 82-2, 56 p.

Koch, D.L., 1970, Stratigraphy of the Upper Devonian Shell Rock Formation of north-central Iowa: Iowa Geological Survey, Report of Investigations 10, 123 p.

Koch, D.L., and Strimple, H.L., 1968, A new Upper Devonian cystoid attached to a discontinuity surface: Iowa Geological Survey, Report of Investigations 5, 33 p.

McGee, W.J., 1891, The Pleistocene history of northeastern Iowa: United States Geological Survey, 11th Annual Report, part 1, p. 199-577.

Mitchell, J.C., 1977, Biostromes and bioherms of the Solon Member of the Cedar Valley Limestone Middle Devonian, Eastern Iowa: unpublished M.S. thesis, University of Iowa, 179 p.

Müller, K.J., and Müller, E.A., 1957, Early Upper Devonian (Independence) conodonts from Iowa, part 1: Journal of Paleontology, v. 31, p. 1069-1108.

Norton, W.H., 1895, Geology of Linn County: Iowa Geological Survey, Annual Report, v. 4, p. 121-195.

Orr, R.W., 1971, Conodonts from Middle Devonian strata of the Michigan Basin: Indiana Geological Survey Bulletin, v. 45, 110 p.

Owen, D.D., 1852, Report of a geological survey of Wisconsin, Iowa, and Minnesota: Lippencott Gambo and Co., Philadelphia, 636 p.

Plocher, O. W., and Bunker, B.J., 1989, A geological reconnaissance of the Coralville Lake area: Geological Society of Iowa, Guidebook 51, p. 1-9.

Rogers, F.S., 1990, Stratigraphy, depositional history, and conodonts of the Little Cedar and lower Coralville formations of the Cedar Valley Group (Middle Devonian) of Iowa: unpublished Ph.D. dissertation, University of Iowa, 97 p.

Slingerland, R., 1986, Numerical computation of co-oscillating palaeotides in the Catskill epeiric Sea of eastern North America: Sedimentology, v. 33, p. 487-497.

Stainbrook, M.A., 1938a, Atrypa and Stropheodonta from the Cedar Valley beds of Iowa: Journal of Paleontology, v. 12, p. 229-256.

Stainbrook, M.A., 1938b, Pentameridae of the Cedar Valley beds of Iowa: American Midland Naturalist, v. 19, p. 723-739.

Stainbrook, M.A., 1940a, Orthoid brachiopods of the Cedar Valley Limestone of Iowa: American Midland Naturalist, v. 23, p. 482-492.

Stainbrook, M.A., 1940b, Elytha in the Cedar Valley beds of Iowa: American Midland Naturalist, v. 24, p. 414-420.

Stainbrook, M.A., 1940c, Prismatophyllum in the Cedar Valley beds of Iowa: Journal of Paleontology, v. 14, p. 270-284.

Stainbrook, M.A., 1941a, Biotic analysis of Owen's Cedar Valley Limestone: Pan-American Geologist, v. 75, p. 321-327.

Stainbrook, M.A., 1941b, Terebratulacea of the Cedar Valley beds of Iowa: Journal of Paleontology, v. 15, p. 42-55.

Stainbrook, M.A., 1941c, Last of great phylum of the cystids: Pan-American Geologist, v. 78, p. 82-98.

Stainbrook, M.A., 1942, Brachiopoda of the Cedar Valley beds of Iowa, Inarticulata, Rhynchonellacea, and Rostrospiracea: Journal of Paleontology, v. 16, p. 604-619.

Stainbrook, M.A., 1943a, Strophomenacea of the Cedar Valley Limestone of Iowa: Journal of Paleontology, v. 17, p. 39-59.

Stainbrook, M.A., 1943b, Spiriferacea of the Cedar Valley Limestone of Iowa: Journal of Paleontology, v. 17, p. 417-450.

Stock, C.W., 1982, Upper Devonian (Frasnian) Stromatoporoidea of north-central Iowa: Mason City Member of the Shell Rock Formation: Journal of Paleontology, v. 56, p. 654-679.

Stock, C.W., 1984a, Upper Devonian (Frasnian) Stromatoporoidea of north-central Iowa: redescription of the type specimens of Hall and Whitfield (1873): Journal of Paleontology, v. 58, p. 773-788.

Stock, C.W., 1984b, The distribution of stromatoporoids in the Upper Devonian of north-central Iowa: in Anderson, W.I. (Ed.), Guidebook for the 48th Annual Tri-State Geological Field Conference, p. 125-129.

Strimple, H.L., 1970, Echinoderm zonules in the Devonian of Iowa: Proceedings of the Iowa Academy of Science, v. 77, p. 249-256.

Tissue, J.S., 1977, A paleoenvironmental analysis of the Middle Devonian sandstones in the Upper Mississippi Valley: unpublished M.S. thesis, University of Illinois, 83 p.

Uyeno, T., 1967, Conodont zonation, Waterways Formation (Upper Devonian), northeastern and central Alberta: Geological Survey of Canada, Paper 67-30, 21 p.

Uyeno, T., 1974, Conodonts of the Waterways Formation (Upper Devonian) of northeastern and central Alberta: Geological Survey of Canada, Bulletin 232, 93 p.

Watson, M.G., 1974, Stratigraphy and environment of deposition of the State Quarry Limestone, Johnson County, Iowa: unpublished M.S. thesis, University of Iowa, 140 p.

Whiting, L.L., and Stevenson, D.L., 1965, The Sangamon Arch: Illinois State Geological Survey, Circular 383, 20 p.

Witzke, B.J. (ed.), 1984, Geology of the University of Iowa campus area, Iowa City: Iowa Geological Survey, Guidebook No. 7, 76 p.

Witzke, B.J., 1987, Models for circulation patterns in epicontinental seas applied to Paleozoic facies of North America craton: Paleoceanography, v. 2, p. 229-248. Witzke, B.J., and Bunker, B.J., 1984, Devonian stratigraphy of north-central Iowa: Iowa Geological Survey, Open-File Report 84-2, p. 107-149.

Witzke, B.J., and Bunker, B.J., 1984, Devonian stratigraphy of north-central Iowa: Iowa Geological Survey, Open-File Report 84-2, p. 107-149.

Witzke, B.J., and Bunker, B.J., 1985, Stratigraphic framework for the Devonian aquifers in Floyd-Mitchell counties, Iowa: Iowa Geological Survey, Open-File Report 85-2, p. 21-32.

Witzke, B.J., Bunker, B.J., and Klapper, G., 1985, Devonian stratigraphy in the Quad-Cities area, eastern Iowa-northwestern Illinois: in Hammer, W.R., Anderson, R.C., and Schroeder, D.A., (eds.), Great Lakes Section, Society of Economic Paleontologists & Mineralogists, 15th Annual Field Conference Guidebook “Devonian & Pennsylvanian Stratigraphy of the Quad-Cities Region Illinois-Iowa,” p. 19-64.

Witzke, B.J., Bunker, B.J., and Rogers, F.S., 1988, Eifelian through Lower Frasnain stratigraphy and deposition in the Iowa area, Central Midcontinent, U.S.A.: in McMillan, N.J., Embry, A.F., and Glass, D.J. (eds.), Devonian of the World, Canadian Society of Petroleum Geologists, Memoir 14, Volume I: Regional Syntheses, p. 221-250.

Youngquist, W.L., 1947, A new Upper Devonian conodont fauna from Iowa: Journal of Paleontology, v. 21, p. 95-112.

Zawistowski, S.J., 1971, Biostromes in the Rapid Member of the Cedar Valley Limestone (Devonian) in east-central Iowa: unpublished M.S. thesis, University of Iowa, 120 p.

Ziegler, W., 1971, Conodont stratigraphy of the European Devonian: Geological Society of America Memoir 127, p. 227-284.

Ziegler, W., and Klapper, G., 1982, The disparilis conodont zone, the proposed level for the Middle-Upper Devonian boundary: Cour. Forsch.-Inst., Senckenberg, v. 55, p. 463-492.

BEDROCK GEOLOGY OF THE CEDAR FALLS/WATERLOO AREA

John R. Groves
Department of Earth Science
University of Northern Iowa
Cedar Falls, IA 50614

The two localities to be visited during this trip are active quarries operated by Basic Materials Corporation (Fig. 1 index map). Limestones of the Middle Devonian Cedar Valley Group are being extracted at each quarry. Beds exposed at Stop 1 are assigned to the Osage Springs,

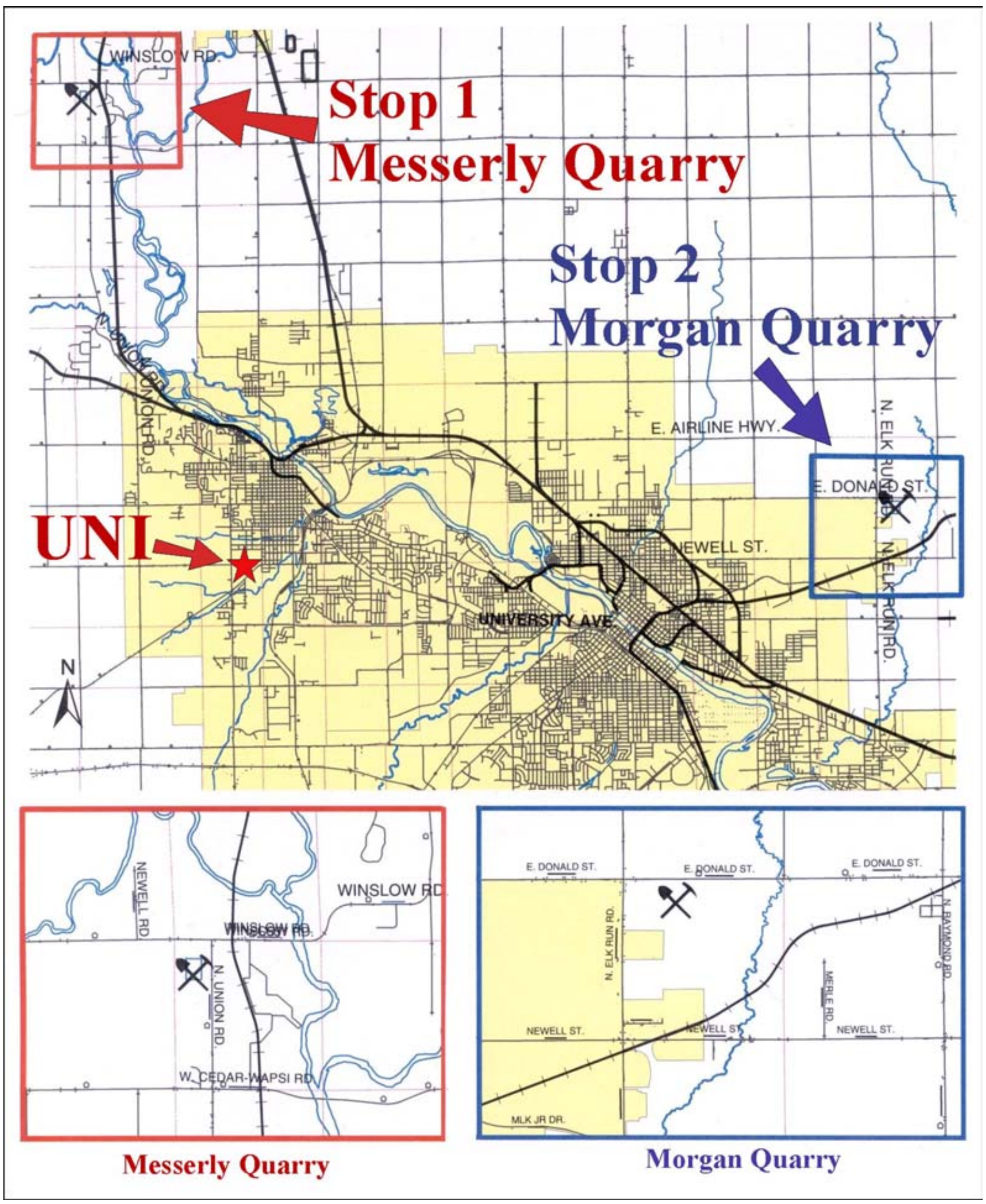


Figure 1. *Map showing location of UNI and the two field trip stops.*

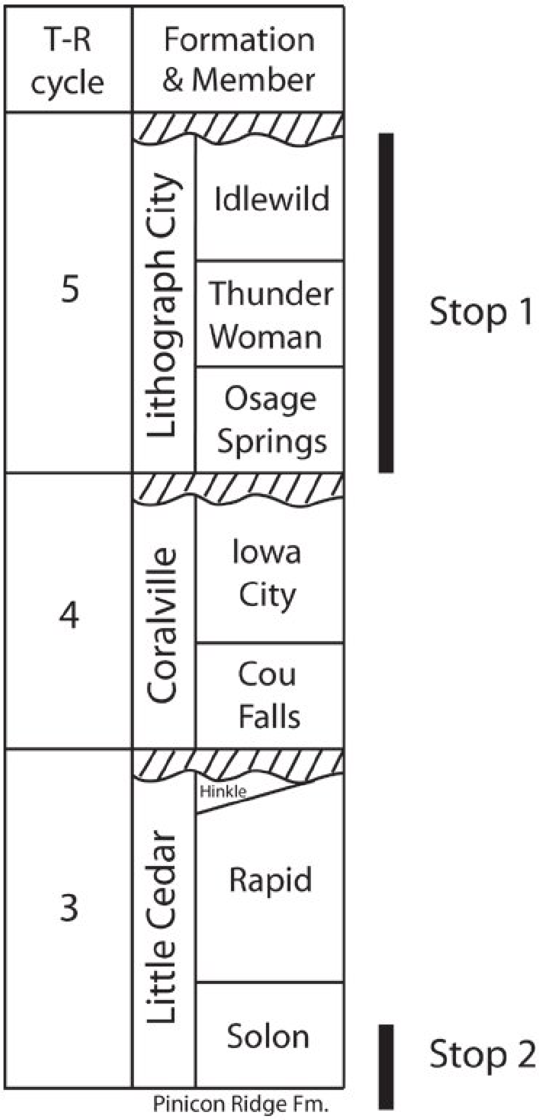


***Figure 2**. Stratigraphic succession of the Middle Devonian Cedar Valley Group (exclusive of the uppermost Shell Rock Formation). Transgressive-regressive (T-R) cycles numbered following Bunker (1988) and Witzke et al. (1988) (adapted from Anderson, 1998).*

Thunder Woman Shale, and Idlewild members of the Lithograph City Formation, with the present floor of the quarry coinciding with the top of the Coralville Formation. At Stop 2 we will examine slightly older beds assigned to the lower part of the Solon Member (Little Cedar Formation) and the upper part of the Pinicon Ridge Formation (Wapsipinicon Group) (Fig. 2 strat column).The late Middle and early Late Devonian strata of eastern Iowa were deposited in response to a series of transgressive-regressive (T-R) cycles (Johnson et al., 1985; Witzke et al., 1988; Bunker, 1988). The lower beds in a typical cycle formed during relatively rapid sea level rise. Middle and upper beds formed during more gradual shallowing. At and near the margins of the depositional basin, cycles were terminated by subaerial exposure and erosion so that each cycle is a distinct unconformity-bounded unit.

STOP 1—MESSERLY QUARRY

The Osage Springs Member is the transgressive, basal portion of the Lithograph City T-R cycle, and it forms the lowest strata above the quarry floor. The upper 8 to 10 feet of the Osage Springs at this locality is a poorly stratified interval of massive stromatoporoids in calcareous shale matrix (Fig. 3). Individual stromatoporoids range in size from a few cm up to 40-50 cm in diameter. They are not preserved in life position, but rather occur as randomly oriented “clasts.” It is unclear whether the stromatoporoids have been transported some distance, or whether they were simply tumbled, possibly by storm action, within their own habitat. Regardless, this distinctive deposit practically begs to be called the “stromglomerate” facies of the Osage Springs.

The overlying Thunder Woman Shale Member is dominantly calcareous shale, but with weakly indurated limestone interbeds present locally. The shale and soft limestone interbeds have no value as aggregate, so they must be separated from sub- and superjacent harder limestones during the crushing phase of the quarrying process.

Limestones of the Idelwild Member sharply overlie the Thunder Woman Shale (Fig. 4). Like the Osage Springs, the Idlewild also contains well preserved stromatoporoids. In contrast to the Osage Springs, however, the Idlewild contains mainly thin, delicately branching stromatoporoids, which are so abundant in certain layers as to be regarded "rock building organisms."

Figure 3. "Stromglomerate" layer within Osage Springs Member of Lithograph City Formation at Messerly Quarry.

Figure 4. Sharp contact between Thunder Woman Shale and Idlewild members of Lithograph City Formation at Messerly Quarry.

Both the massive and the branching stromatoporoids can be safely collected in rubble along the roads and at the margins of the quarry. The Idlewild at this locality varies in thickness from 10-12 feet in the southeast corner of the quarry to less than six feet along the western side of the quarry. This abrupt thinning is attributed to post-Devonian erosional truncation, most likely Pleistocene glacial scouring.

STOP 2—MORGAN QUARRY

The lowest beds exposed in the Morgan Quarry are assigned to the Pinicon Ridge Formation of the Wapsipinicon Group. The upper Pinicon Ridge here is represented by the Davenport Member, which is roughly 10 feet thick and consists of highly brecciated limestone. Breccia within the Davenport Member is thought to have formed by solution of interbedded evaporite layers, followed by collapse and cementation of remaining limestone clasts.

The Solon Member of the Little Cedar Formation unconformably overlies the Pinicon Ridge Formation. The Solon Member is approximately 40 feet thick locally, but the upper part of the unit has been erosionally truncated beneath the Pleistocene till. The Solon consists of yellow and tan, well bedded limestones with abundant fossils in places. Spiriferide brachiopods and massive stromatoporoids, in particular, are common in these beds.

A NOTE ON STROMATOPOROIDS

Stromatoporoids are unique animals that grew in domal, tabular, encrusting, dendroid, or digitate shapes. They can occur as massive individuals or as delicately branching ones. Although stromatoporoids exhibit a wide range of morphologies, all can be identified by their distinctive internal structure.

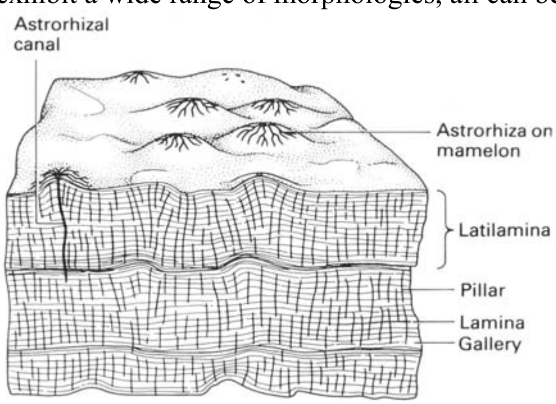


Figure 5. Sketch of the stromatoporoid Actinostroma showing internal structure as seen in longitudinal section and growth surface with astrorhizae and mamelons (from Boardman et al., 1987).

Figure 6. Thin section photomicrograph of the Middle Devonian stromatoporoid Anostylostroma showing characteristic internal structure of galleries defined by laminae and pillars (from Boardman et al., 1987).

Individual stromatoporoids secreted an open calcareous skeleton, or coenosteum, consisting of a network of structural elements aligned perpendicular and parallel to the growth surface (Figures 5 and 6). Single, sheet-like layers parallel to the growth surface are called laminae. Spaces between laminae are called galleries. During life, the galleries may have been filled with sea water or with soft tissue of the organism. Pillars are rod like elements oriented perpendicular to laminae. Low mounds on the growth surface are termed mamelons.

Stromatoporoids originated in Ordovician time, became very diverse and abundant in Silurian and Devonian time, and then apparently became extinct in late Devonian time. Stromatoporoid-like sponges reappeared in the Mesozoic Era, but the lengthy gap between the last Paleozoic forms and the first Mesozoic forms suggests that the morphologic similarity between the two groups may be a product of convergence and not common ancestry.

Certain stromatoporoids strikingly resemble extant sclerosponges, a group of cryptic (crevice- and cave-dwelling) marine organisms that were first discovered in the Caribbean and Indo-Pacific oceans in the 1960's (Hartman and Goreau, 1970). In particular, both stromatoporoids and sclerosponges possess mamelons and astrorhizae, which in sclerosponges house radial canal systems in which water flowing through the animal is collected before exiting from a central opening (Fig. 7). This shared feature is so remarkable that some taxonomists now consider stromatoporoids to be ancient sclerosponges. Again, however, the significant occurrence gaps between Paleozoic, Mesozoic and modern forms are equally consistent with repeated instances of convergence, and the biologic affinity of stromatoporoids remains unclear.

Stromatoporoids were most common in shallow, open marine shelf settings. They, along with certain corals, formed recurring reef communities during Middle Paleozoic time (Silurian and Devonian periods).

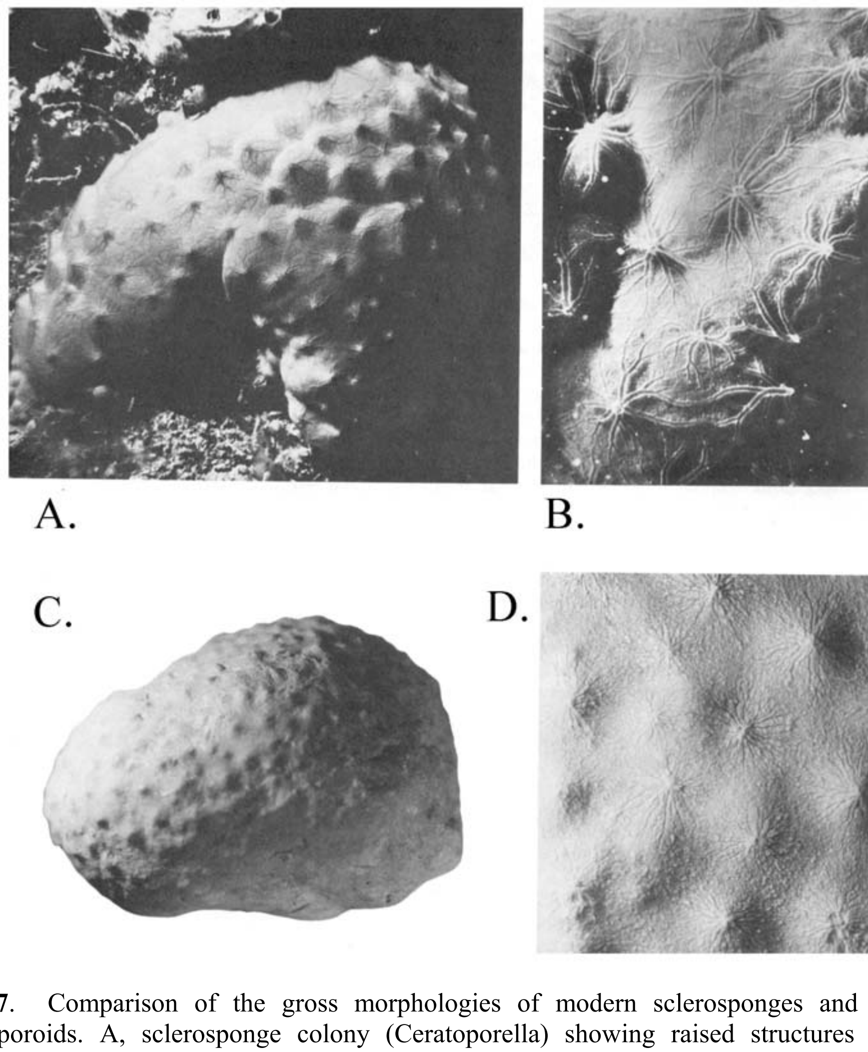


Figure 7. Comparison of the gross morphologies of modern sclerosponges and Devonian stromatoporoids. A, sclerosponge colony (Ceratoporella) showing raised structures on which astrorhizae are centered; B, close-up of astrorhizae in Ceratoporella; C, hemispherical Devonian stromatoporoid with raised mamelons; D, close-up of Devonian stromatoporoid showing astrorhizae centered on mamelons (from Raup and Stanley, 1971).

REFERENCES

Anderson, W. I. 1998. Iowa's geologic past: Three billion years of change. University of Iowa Press, Iowa City.

Boardman, R. S., A. H. Cheetham, and A. J. Rowell (eds.). 1987. Fossil invertebrates. Blackwell Scientific Publications; Palo Alto, Oxford, London, Edinburgh, Boston, Melbourne, 713 p.

Bunker, B. J. 1988. Late Middle through lower Upper Devonian stratigraphy across eastern Iowa. In G. A. Ludvigson and B. J. Bunker (eds.), New perspectives on the Paleozoic history of the upper Mississippi Valley: An examination of the Plum River fault zone. Iowa Geological Survey Bureau Guidebook 8.

Hartman, W. D., and T. F. Goreau. 1970. Jamaican coralline sponges: their morphology, ecology and fossil relatives. Symposium of the Zoological Society of London, 25:205–243.

Johnson, J. G., G. Klapper, and C. A. Sandberg. 1985. Devonian eustatic fluctuations in Euramerica. Geological Society of America Bulletin, 96:567-587.

Raup, D. M, and S. M. Stanley. 1971. Principles of invertebrate paleontology, 2nd Ed. W. H. Freeman & Company; San Francisco, 481 p.

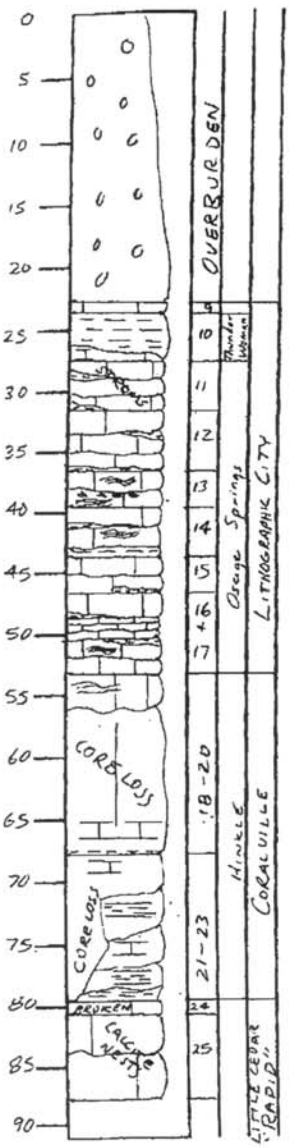
Witzke, B. J., B. J. Bunker, and F. S. Rogers. 1988. Eifelian through lower Frasnian stratigraphy and deposition in the Iowa area, central midcontinent, USA. In N. J. McMillan, A. F. Embry, and D. J. Glass (eds.), Devonian of the World. Canadian Society of Petroleum Geologists Memoir 14.

Messerly CO4-2 Core

Basic Materials Corp

T90N, R14W, Sec 14 , Black Hawk Co

west of current pit



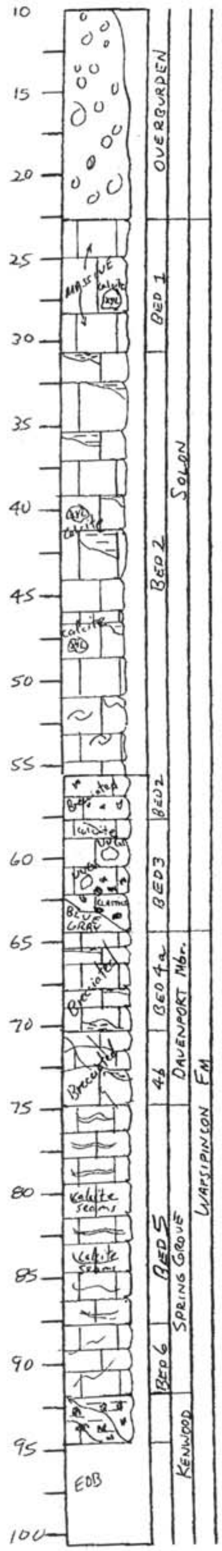
	Description	**Thickness**
	OVERBURDEN.	
0-22.5'	Overburden	22.5'
	LITHOGRAPHIC CITY.	
22.5-24.3'	Bed 9; Limestone, gray/tan fine grained, massive, sublithographic in places.	1.8'
24.3-27.4'	Bed 10; Shale, tan, soft, very calcareous last 1'.	3.1'
27.4-31.3'	Bed 11; Limestone, stroms interbedded with shale and clay, stroms are gray/brown, shale is yellow tan, fine grained.	3.9'
31.3-36.3'	Bed 12; Limestone, argillaceous, yellow/tan, laminated appearance, fine to sublithographic, thin shale seam at base.	5.0'
36.3-39.6'	Bed 13; Limestone, gray/tan, sublithographic, brecciated appearance in middle of bed, idiostroms, intermediate laminations and platy, fine to sublithographic, shale seam at base.	3.3'
39.6-43.7'	Bed 14; Limestone, gray/tan, fine to sublithographic, shale partings on bedding planes, laminated bedding in places, 0.7' yellow green shale lens at base.	4.1'
43.7-46.7'	Bed 15; Limestone, gray/brown, few tan shale partings on bedding planes,sublithographic, weathered 1" tan calcareous shale seam at base.	3.0'
46.7-53.1'	Beds 16 & 17; Limestone, light gray, laminated to platy, fine grained, shale partings on bedding planes, slightly argillaceous, 5" non platy limestone lens at base, thin shale seam at base.	6.4'
	CORALVILLE.	
53.1-67.9'	Beds 18-20? Limestone at top, gray/brown, sublithographic, broken rubble after 2.9', shale partings, 2' limestone gray and medium/sublithographic in lower part with tan 1" shale seam at base; core loss, 8-10'.	14.8'
67.9-79.6'	Beds 21-23; Shale and Limestone; 6'+ core loss, 1.4' limestone gray/tan and lithographic followed by 8" yellow clay/shale lens, 1' tan/gray vesicular limestone, 1.2' argillaceous limestone, 6" calcareous shale lens, 0.8' gray hard limestone with 4" yellow/green shale lens at base.	11.7'
	LITTLE CEDAR (RAPID MEMBER).	
79.6-80.6'	Bed 24; Limestone, dolomitic, brown, fine grained, broken.	1.0'
80.6-87.8'	Bed 25; Limestone, dolomitic, calcite nests, large weathered vug in middle of bed, gray/brown, fine, massive, small brecciated appearing lens 2' from top of bed.	7.2'

Core length: 65.3'; core recovery, 74%. Core loss due to fine or weathered material which either washed away or was pushed aside by drill. No evidence of karst zones in missing core loss.

Sherman Lundy,
Geologist

Morgan C97-1 Core

Basic Materials Corp
T89N, R12W, Sec 15 , Blackhawk Co



Description		**Thickness**
0-22.6'	Overburden	
	Little Cedar Formation Solon Member	
22.6-30.74'	Bed 1; Limestone, yellow/tan massive in places, large calcite seam in middle of bed, fine to medium grained, manganese dendrites.	8.1'
30.74-57.9'	Bed 2; Limestone, blue/gray argillaceous, thin calcite seams, massive, fine to sublithographic, one large 4" calcite mass in middle of bed; brachs in lower part of bed, brecciated zone in lower 2" of bed.	27.16'
57.9-64.5'	Bed 3; Limestone, yellow/tan many calcite vugs, becomes blue gray in places (probably slightly argillaceous near bottom of bed) medium grained, becomes increasingly clastic toward bottom of bed.	6.6'
	Wapsipincon Formation Davenport Member	
64.5-70.3'	Bed 4a; Limestone, gray/ brecciated-small fragments < 1 cm in size; grades to large > 1 cm fragments in bed below.	5.8'
70.3-74.80'	Bed 4b; Limestone, gray, brecciated, > 1 cm fragments, clasts are white and gray, fine grained, argillaceous in places.	4.5'
	Spring Grove Member	
74.8-87.8'	Bed 5; Limestone, off yellow and white to a light red tan; many laminations appearing as thin beds or seams in massive segments, very fine grained in top 1.6', calcite seams.	13.0'
87.8-91.8'	Bed 6; Limestone, white to tan white, medium grained, finer appearing laminations than bed above.	4.0'
	Kenwood Member.	
91.8-94.7'	Bed 7; Shale, very calcareous very brecciated with mixture of limestone and gray shale fragments.	2.9'

Total Core Length: 72.1'; Core recovery about 100%. Similar to earlier cores from this quarry.

GSA GSI
Sherman Lundy
Consulting Geologist
4658 Summer St.
Burlington, Iowa 52601
Ph. 319-752-2895
SEPM NAGT

QUATERNARY GEOLOGY OF THE CEDAR FALLS/WATERLOO AREA

James C. Walters
Department of Earth Science
University of Northern Iowa
Cedar Falls, IA 50614

THE IOWAN SURFACE

The Cedar Falls/Waterloo area lies in the heart of one of Iowa's largest landform regions: the Iowan Surface (Fig. 1). The topography of this region is characterized by a gently rolling landscape and broad open vistas (Prior, 1991). Earlier workers thought the origin of this landscape region was due to an "Iowan Glacier" that invaded the area sometime between the Illinoian and Wisconsinan glacial periods. The "Iowan" was later assigned to the earliest substage of Wisconsinan. Because of the lack of exposures in this area, the age and origin of this supposed glacial drift was debated for many years. Finally in the 1960s, Robert Ruhe and his coworkers undertook a detailed investigation of these sediments utilizing drilling and radiocarbon dating. They determined that the so-called Iowan drift did not exist; there had not been an Iowan Glacier at all (Ruhe, 1969). Instead, they showed that the landscape and sediments of this part of the state were actually a result of severe erosion. The Iowan Erosion Surface, or simply Iowan surface as it came to be called, is an extensive erosion surface complex cut into Pre-Illinoian-age glacial deposits (Hallberg *et al*., 1978).

The Iowan Surface today is described as a multi-leveled erosion surface with a stepped topography cut into Pre-Illinoian till. These stepped surfaces occur in a subdued and gradual progression from upland drainage divides down to the major stream valleys (Prior, 1991). The formation of the steps or levels took place during periods of accelerated erosion involving steam action, slope wash, and wind deflation. Studies have shown that one of the more recent and one of the most severe of these episodes of erosion took place between 21,000 and 16,500 years ago during the coldest part of the Wisconsinan. Investigations involving analysis of fossil pollen, plant macrofossils, small mammals, insects, and molluscs at various sites in Iowa and adjacent states provide evidence that this region had a cold climate with open tundra conditions (Baker *et al*., 1986, 1989, 1991).

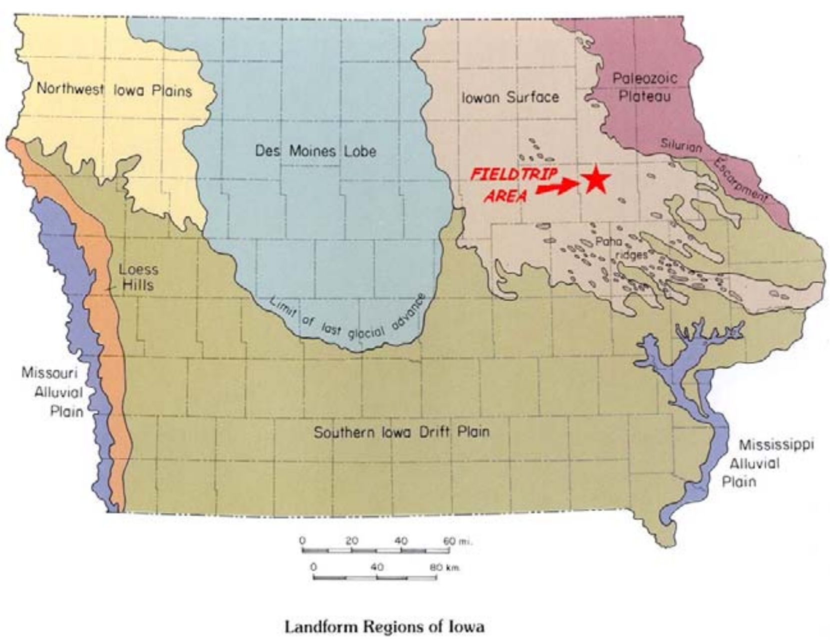


Figure 1. Location of field trip area on map of Landform Regions of Iowa (map fro Prior, 1991).

Additional studies have led us to conclude that a periglacial environment existed in northeast Iowa during this period of time. Intensive freeze-thaw activity, solifluction, strong winds, and other periglacial processes must have been occurring. Among other things, this resulted in the formation of an erosion surface on the Pre-Illinoian deposits of the area and the development of a residual lag deposit or stone line (Iowan pebble band) as the finer sediments were removed. Along drainage divides, scattered uneroded remnants of the original Pre-Illinoian topography remained above the stepped surfaces. These elongate ridges and scattered elliptical hills were capped with loess and eolian sands as the surrounding landscape was being severely eroded. Paha, as they are now called, have a northwest-southeast orientation and consist of a core of Pre-Illinoian till, with a paleosol (instead of the stone line the surrounding erosion surface exhibits) and overlying eolian sediments. Permafrost, or permanently frozen, ground must have also existed during this period of intense cold, and ice-wedge polygons formed in the Pre-Illinoian tills. Relict polygonal patterned ground and ice-wedge casts, fillings of the former ice wedges, are common features of the Iowan Surface (Walters, 1994).

THE CEDAR VALLEY

Although the term Cedar Valley is used mostly in a political/geographical sense, there is, in fact, a geomorphological Cedar Valley. The Cedar Valley is a result of glacial, fluvial, and eolian processes occurring during late Pleistocene to Holocene time. The stage was set with a blanket of Pre-Illinoian till over Devonian-age bedrock sometime between 2 million and about 500,000 years ago. We know there must have been at least two episodes of continental glacial activity during Pre-Illinoian time. The last ice sheet exited the area by 500,000 years ago, and all later glacial activity in Iowa did not enter this part of the state. The ancestral Cedar River probably began cutting its valley shortly after the last ice sheet left this area and perhaps was in existence even in between these early episodes of continental glacial activity.

The most recent Pleistocene glacier, the Wisconsinan ice sheet, covered only the central part of the state and extended as far south as where the city of Des Moines sits today. This lobe of ice, known as the Des Moines Lobe, lay to the north and west of the Cedar Falls/Waterloo area, and must have shed enormous volumes of meltwater to the Cedar River. The Cedar developed into a typical glacial meltwater stream, with numerous braided channels and huge amounts of glacially derived sediments. After the Des Moines Lobe retreated from Iowa, these large volumes of glacial meltwater no longer influenced the development of the Cedar River Valley. The river became much reduced in size, and the large valley it had cut was now out of proportion to the size of the river. In fact, the Cedar River can be considered an underfit stream, a stream that appears too small to have eroded the valley in which it now flows.

In more recent times, but perhaps starting as early as about 20,000 years ago, strong winds blowing along the abandoned Pleistocene floodplains of the Cedar River created dunes and sand sheets in and adjacent to the Cedar Valley. All of these eolian features have a northwest-southeast orientation and they are mostly restricted to the edges of the Cedar Valley, but they also continue in places up unto the surrounding glacial topography. In fact, in some cases dunal features cap the highest points of the glacial landscape and the eolian sands and silts also cap paha on the surrounding Iowan Surface.

MESSERLY QUARRY

Quaternary sediments at the Messerly Quarry consist of approximately 7 m of Pre-Illinoian till overlain by 0.5 to 1 m of loamy sediment (Fig. 2). The lower portion of the till is a grayish-brown color and is unoxidized and leached. The upper 2.5 to 3 m of till is oxidized and unleached and shows a strong yellowish-brown color. Although the surface of the till and overlying loamy sediments is mostly disturbed due to the berming process which occurred as a part of developing the quarry, one can still make out a stone line in places (or at least remnants of the stone line) at the till surface. Occasional ventifacts, or wind-faceted stones, can be found in the stone line, attesting to the strong winds which must have existed in this area during the latter stages of formation of the Iowan Surface and before the loamy (mostly eolian) sediments covered this surface. Also notable are the large glacial erratics, some over 2 m in diameter, that have been pushed to the edge of the quarry during quarry development. Several of these exotic boulders show faceting and striations from having been dragged along at the base of the ice sheet.

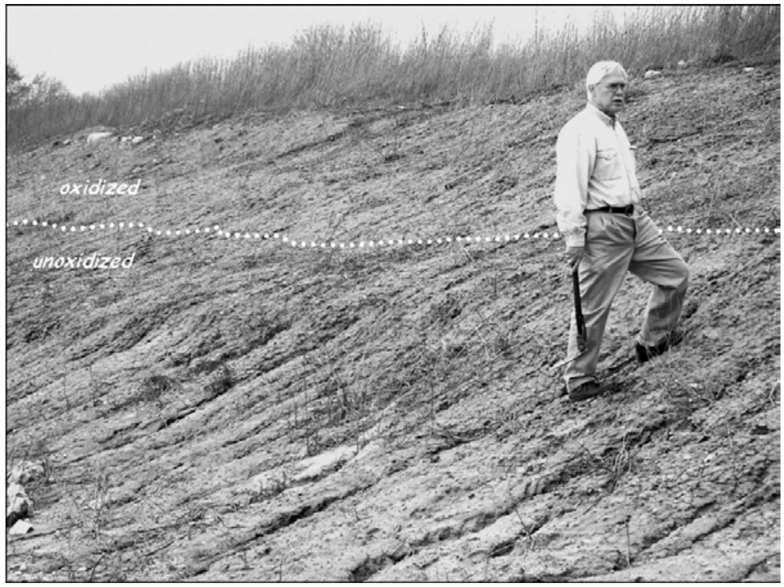


Figure 2. Contact between oxidized and unoxidized Pre-Illinoian till at the Messerly Quarry.

MORGAN QUARRY

Pre-Illinoian till up to 20 m thick is exposed on the south side of the Morgan Quarry. Sections also exist on the west and north sides, but they are not as thick. At the northwest side of the pit, where the Solon member of the Little Cedar Formation has not yet been excavated but the overlying glacial till has been removed, there are several places where striations and glacial polish can be seen on the limestone bedrock (Fig. 3). The striations show an azimuth of 290-294 degrees, indicating that the earliest Pre-Illinoian ice sheet in this area came from a westerly-northwesterly direction.

Examination of the sediments here suggests that there may be two Pre-Illinoian tills present. The lower unit, about 6 m thick, is separated from the upper unit (about 14 m thick) by a gently sloping surface with a distinct color change. The lower unit is grayish-brown in color, whereas the upper unit is yellowish-grayish-brown in its lower part and more yellowish-brown in its upper part. The surface that separates the two units is about 0.2 to 0.5 m thick and is a dark reddish brown color. Spruce (?) wood fragments with some larger pieces up to 30 cm long can be found at the top of this thin dark layer. Faint stratification can be seen in both the upper and lower till units. In the southwest end of the pit, stratified sands and gravels with steeply dipping beds can be seen along with some large areas of grayish-brown silts with occasional small pebbles scattered though it in places.

Figure 3. Glacial striations on limestone bedrock at the Morgan Quarry. Azimuth is 290 degrees.

The top of the section, as is the case at the Messerly Quarry, has been bermed as part of the quarry development. Therefore, the top of the till and the loamy sediments overlying the till are disturbed. However, remnants of a stone line can be seen in places. A short distance west of the Morgan Quarry, Basic Materials, Corp. has developed a

Figure 4. Polygonal pattern of ice-wedge casts at the Evansdale Property. Approximately 4 m of overlying Pre-Illinoian till has been removed here, so the surface shows the bottom of the ice-wedge casts as they penetrate into the lower unoxidized till.

shallow excavation (3 to 5 m) in Pre-Illinoian till, and if time permits and weather conditions are suitable, those interested can take a 5 minute walk to what is called the Evansdale Property. This is a west-facing exposure that shows the top part of the Pre-Illinoian till and a well-developed stone line, with loamy sediments about .5 to 1 m thick at the top of the section. Occasional ventifacts can be found in the stone line, but perhaps the most interesting feature here is the presence of ice-wedge casts. These are sediment-filled wedges which formed as the thawing permafrost which existed approximately 21, 000 to 16, 500 years ago thawed with the warming climate. The ice of the ice wedges melted out and filled with sediments washed and blown into the opening voids. Also, at this site, the surface in front of the exposure has been scraped level and here in some places the remnants of the polygonal pattern of the ice-wedge casts can be observed (Figure 4). The wedges penetrate down into the unoxidized till, so the color change from the orangish-brown sediment of the wedges contrasts strongly with the grayish color of the till.

REFERENCES

Baker, R.G., Rhodes, R.S., II, Schwert, D.P., Ashworth, A.C., Frest, T.J., Hallberg, G.R., and Janssens, J.A., 1986. A full-glacial biota from southeastern Iowa, USA: Journal of Quaternary Science, v. 1, p. 91-107.

Baker, R.G., Sullivan, A.E., Hallberg, G.R., and Horton, D.G., 1989. Vegetational changes in western Illinois during the onset of Late Wisconsinan Glaciation: Ecology, v. 70, p. 1363-1376.

Baker, R.G., Schwert, D.P., Bettis, A.E., III, Kemmis, T.J., Horton, D.G., and Semken, H.A., 1991. Mid-Wisconsinan stratigraphy and paleo-environments at the St. Charles site in south-central Iowa: Geological Society of America, Bulletin v. 103, p. 210-220.

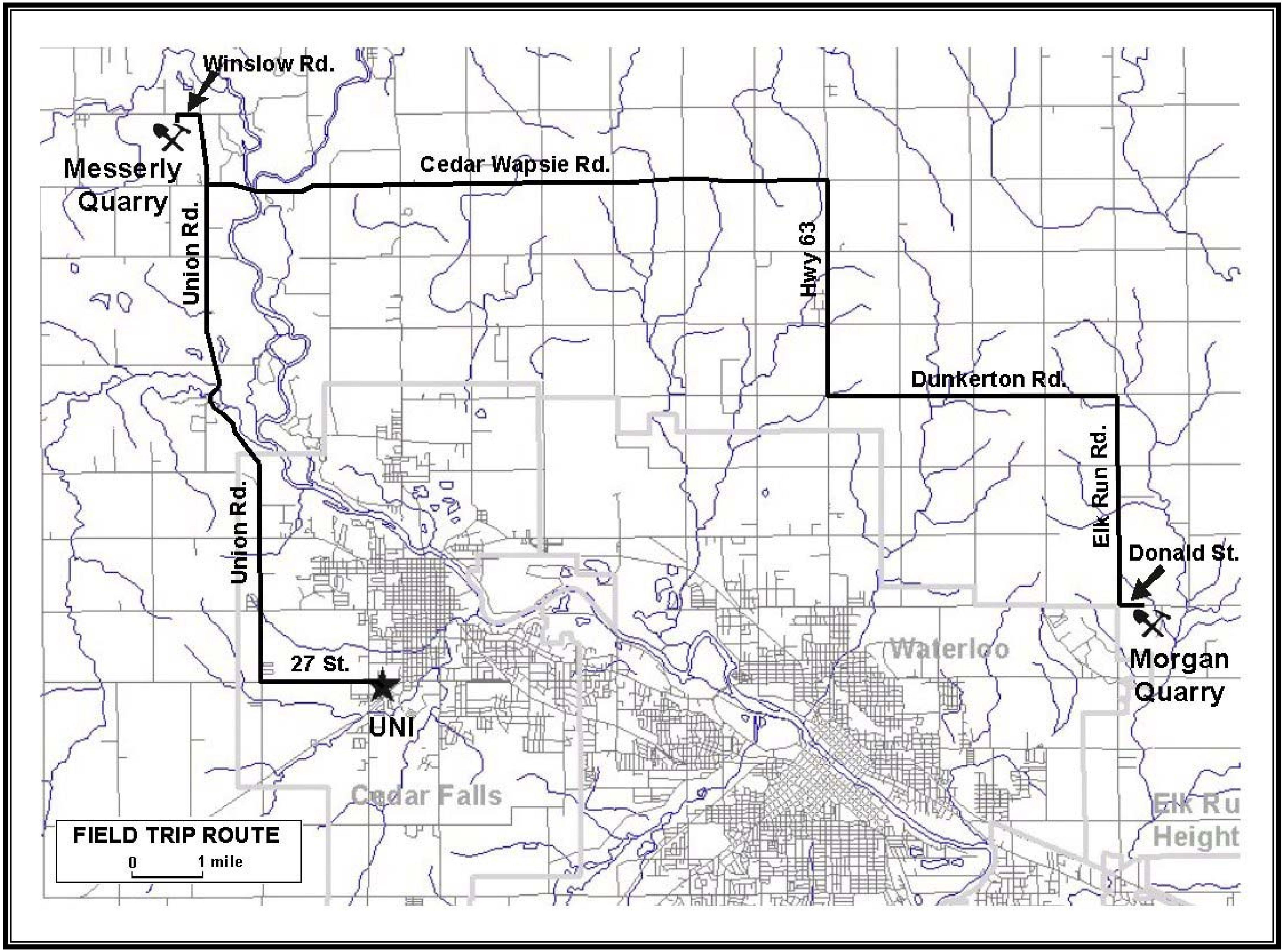
Hallberg, G.R., Fenton, T.E., Miller, G.A., and Lutenegger, A.J., 1978. The Iowan Erosion Surface: An Old Story, An Important Lesson and Some New Wrinkles in 42nd Tri-State Geological Field Conference Guidebook on Geology of East-Central Iowa, Iowa Geological Survey, Iowa City, p. 2-1 to 2-94.

Prior, J.C., 1991. *Landforms of Iowa*. University of Iowa Press, Iowa City, 154 p.

Ruhe, R.V., 1969. *Quaternary Landscapes in Iowa*: Iowa State University Press, Ames, Iowa, 255 p.

Walters, J.C., 1994. Ice-wedge casts and relict polygonal patterned ground in northeast Iowa, U.S.A.: Permafrost and Periglacial Processes, v. 5, p. 269-281.

Geological Society of Iowa
109 Trowbridge Hall
Iowa City, Iowa 52242-1319
http://www.igsb.uiowa.edu/gsi


Winslow Rd.
Messerly Quarry
Cedar Wapsie Rd.
Union Rd.
Hwy 63
Dunkerton Rd.
Elk Run Rd.
Donald St.
Morgan Quarry
Union Rd.
27 St.
UNI
Waterloo
Cedar Falls
FIELD TRIP ROUTE
0
1 mile