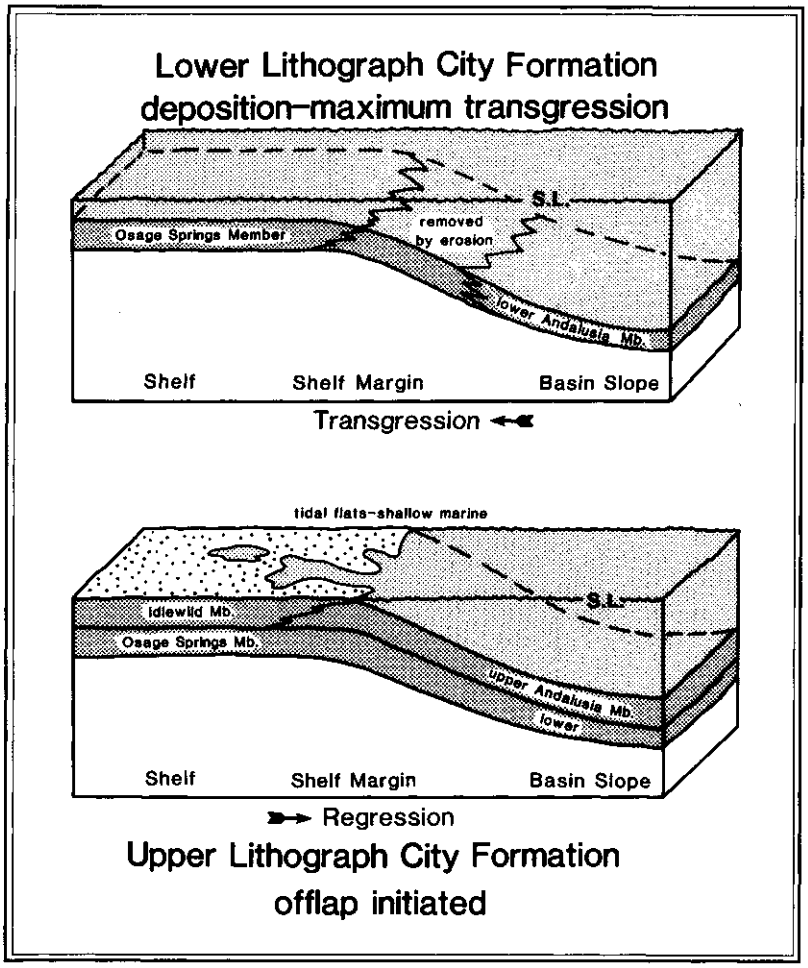
UPPER CEDAR VALLEY STRATIGRAPHY

NORTH-CENTRAL IOWA • LITHOGRAPH CITY FORMATION

Bill J. Bunker Brian J. Witzke Jed Day



GEOLOGICAL SOCIETY OF IOWA

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"It is quite impossible to present a complete section of the Minnesota Devonian at the present time. In fact is may never be possible to complete it satisfactorily unless at some future time the region should be drilled for water or other natural resources that may seem worth while. ... The Devonian of Manitoba and the Mackenzie valley carry a few of the same fossil forms that are common in the Cedar Valley limestone of Minnesota. ... In short, so remote is the relationship between the fauna of the Minnesota Devonian and that known from Manitoba and the Mackenzie valley that the idea of a direct sea connection between these two regions, during the deposition of the Cedar Valley limestone, should be abandoned." (Stauffer, 1922)

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LITHOGRAPH CITY FORMATION

by
Bill J. Bunker[1], Brian J. Witzke[1], and Jed Day[2]

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HISTORICAL

The Cedar Valley Formation forms the bedrock surface over a large portion of north-central and northeast Iowa, including parts of Fayette, Winneshiek, Bremer, Chickasaw, Howard, Mitchell, Floyd, Butler, Cerro Gordo, and Worth counties. It is exposed in numerous quarries, road cuts, and river valley outcrops throughout the region.

The Cedar Valley Formation was originally named for the series of exposures of Devonian carbonate rocks along the valley walls of the Cedar River, although no type locality was ever designated (McGee, 1891). As originally defined, it included the Devonian sequence above the Silurian unconformity and below the "Hackberry Shale" (Lime Creek Formation). Subsequent recognition of the Wapsipinicon (Norton, 1895) and Shell Rock (Belanski, 1927, 1928) formations restricted the Cedar Valley to a position between those two formations.

The Cedar Valley Formation is best known from exposures in the Johnson County, Iowa, area where the formation was subdivided, in ascending order, into three members: the Solon, Rapid, and Coralville. However, with regards to the Cedar Valley of northern Iowa, Thomas (1920, p. 410) noted that the Cedar Valley subdivisions in Johnson County could not be applied in northern Iowa. Fenton (1918) referred to the Bloody Run quarries and Belanski (circa 1927, unpublished field notes) applied the term "Bloody Run Stage" to the series of rocks that lay beneath the Shell Rock Formation, but this terminology was never formally adopted. Nelson (1939, p. 41-43) stated "... A careful examination of the sections given typical of the Cedar Valley in central Iowa, and a brief field examination of the type sections of the Coralville and Littleton members of the Cedar Valley indicates several distinct differences between the Cedar Valley of the central and eastern areas of Iowa and the northern phase as seen in Floyd County. The most striking differences are the almost complete lack of fossiliferous beds and the presence of a large amount of dolomite in the lower portions of the Floyd County sections as compared with the southern and eastern facies. ... Because of these differences and the lack of any similarity in the sections observed by the writer it has not seemed possible to correlate the Cedar Valley of Floyd County with the various members of the southern and eastern part of Iowa. It is suggested that the Cedar Valley as exposed in Floyd County be divided into two members, the upper called the Floyd member and exposed in the Wilcox quarry in the northwest part of Floyd. ... The lower beds, exposed in the quarry at the bridge in Floyd and along the Cedar River in the southern part of the county may be designated the Riverton member from its

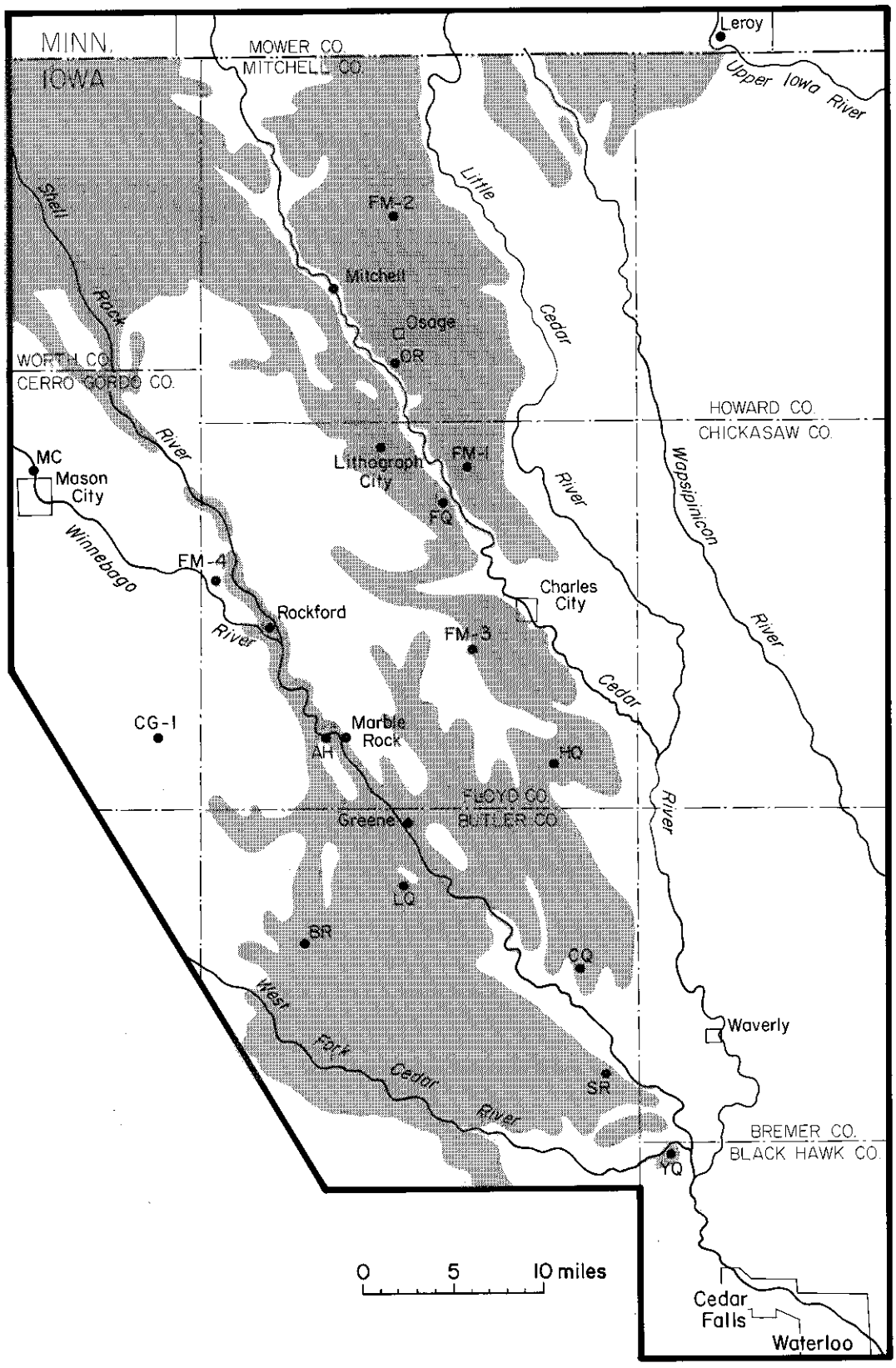

FIGURE 1. Map showing the general outcrop (shaded) area of the Lithograph City Formation in north-central Iowa. Shell Rock River valley exposure belt in west-central Floyd County is exaggerated for mapping purposes. Site abbreviations and locations noted in accompanying figures and text.

development in Riverton township, with the best sections available at Floyd and in the bluffs and quarries along the Cedar River in sections 27, 28, 33, and 34, T. 95 N., R. 15 W., Riverton township about 5 miles southeast of Charles City." Unfortunately Nelson's stratigraphic framework was never formally adopted; both terms however were preoccupied, the Floyd as a Mississippian stratigraphic unit in Georgia, and the Riverton as a Pennsylvanian unit in southern Kansas. Stainbrook (1944) also noted that the "exposures near Floyd when arranged in chronological order yield a nearly complete section of the upper half of the Cedar Valley" in Floyd County, but did not propose any stratigraphic subdivisions or make any attempts at correlation with the Johnson County sections.

Kullman (1968) attempted to map regional structure in Floyd County utilizing the supposed Rapid-Coralville contact as a datum. His criteria for recognition of this contact in the subsurface was based largely upon the change from limestones of the Coralville to dolomites of the underlying Rapid. While this limestone to dolomite transition may have some utlization locally as a structural datum it by no means represents the Coralville-Rapid contact within the northern Iowa area.

Miscorrelation of the eastern Iowa Cedar Valley member subdivision with the Devonian sequence exposed in northern Iowa and southeastern Minnesota persisted until the mid-1980's. Strata previously included in the "Solon Member" of northeast Iowa and adjacent Minnesota (Dorheim and Koch, 1966; Kohls,1961; Mossler, 1978) are now included in the Spillville Formation (Klapper and Barrick, 1983; Bunker et al., 1983; Witzke and Bunker, 1984). "Lower Rapid" strata in the same area (Dorheim and Koch, 1966) are now included in the Wapsipinicon Formation (Bunker et al., 1983; Witzke and Bunker, 1984). The lithologic characteristics of the rocks included in the Cedar Valley of northern Iowa are different for the most part than those of the Cedar Valley in the Johnson County area of eastern Iowa (Witzke and Bunker, 1984; Witzke et al., 1985) . Therefore exact regional correlations of the three eastern Iowa members of the Cedar Valley Formation with equivalent rocks in northern Iowa are not yet known with a great deal of certainty. Because of these uncertainties, use of the terms "Solon," "Rapid," and "Coralville" in northern Iowa has been discouraged (Witzke and Bunker, 1984).

STRATIGRAPHY

The thickest and most complete sequence of Cedar Valley strata in the Devonian outcrop belt of the central Midcontinent region is found in northern Iowa. In 1984 Witzke and Bunker recognized and proposed a new lithostratigraphic framework for the Cedar Valley of northern Iowa. They informally subdivided the Cedar Valley into five members, designated in ascending order, Units A through E. Units A, B, and C were identified by their prominent cyclic character, and the stratigraphic contacts between them were drawn at the top of each depositional cycle. Each cycle records a major transgressive - regressive depositional sequence. Fossiliferous dolomitic intervals record deposition in open-marine carbonate shelf environments during successive transgressive phases, whereas laminated, intraclastic, and brecciated carbonates record deposition in shallow, restricted subtidal and tidal flat settings during each regressive phase. Intervening carbonate strata (Units D & E) between the top of Unit C and the base of the Lime Creek

Formation were informally included in an "Upper Cedar Valley Formation." Witzke and Bunker (1984) proposed a possible correlation equating Unit E with the Shell Rock Formation, and following stratigraphic studies of four new core holes in Floyd and Mitchell counties they assigned Unit E to the Shell Rock in 1985. Additional studies of the Floyd-Mitchell cores also pointed out the general impracticality of consistently recognizing the stratigraphic position of the Unit C - Unit D contact. The base of Unit D was previously drawn at the base of the first fossiliferous unit above the lower Unit C vuggy and fossiliferous interval. The discovery of some fossiliferous beds within strata apparently equivalent to upper Unit C obscured the distinction of this contact. Therefore, in order to establish a more usable stratigraphic framework, Witzke and Bunker (1985) expanded the definition of Unit C to include Unit D of their earlier report (Witzke and Bunker, 1984).

Unit C strata forms the bedrock surface over a large portion of north-central Iowa, in particular Floyd, Mitchell, and Butler counties (Fig. 1). Because of the widespread nature of this unit, the numerous exposures in this area, and the distinct stratigraphic position of the unit with respect to previously-named intervals, a more formal stratigraphic terminology is recommended. Although it is realized that the Code of Stratigraphic Nomenclature does not recognize a guidebook as a proper forum for defining and establishing new stratigraphic units, the following discussion and definitions of new stratigraphic terminology are offered in order to help geoscientists of Iowa better acquaint themselves with the Devonian of Iowa. Terminology will be formally defined in a subsequent publication.

The formulation of the lithostratigraphic framework of the Cedar Valley of northern Iowa was based upon the observation of the cyclic nature of the rock record as noted at the beginning of this section. The basic elements of each depositional cycle consist of a basal transgressive marine unit and an upper regressive carbonate unit, which form a series of natural subdivisions within the context of a larger stratigraphic framework (i.e. a depositional cycle). Each depositional cycle in turn forms a natural subdivision within the context of a larger stratigraphic hierarchy (i.e. one large-scale transgressive-regressive cycle of deposition). Witzke and Bunker (1984) originally assigned each depositional cycle to the Cedar Valley Formation extending the definition to include their Unit E (now assigned to the Shell Rock) in an "Upper Cedar Valley" subdivision. Because of the ability to recognize these individual depositional cycles and their individual transgressive-regressive elements, it is recommended that the Cedar Valley be elevated to group status (as suggested by Witzke et al., 1985) with the inclusion of the Shell Rock as the uppermost formation within the Cedar Valley Group (i.e. the one large-scale depositional cycle). Although the elevation of the Cedar Valley to group status affords a meaningful hierarchical scheme for strata in northern Iowa and the central Iowa subsurface, nomenclatural problems in the classic Johnson County area have not been rectified.

LITHOGRAPH CITY FORMATION

The importance of distinguishing "Upper Cedar Valley" strata from type Coralville strata in east-central Iowa necessitates the development of a new formal stratigraphic terminology in northern Iowa. The development of this new terminology will also have direct application to previously defined strata in east-central Iowa (i.e. State Quarry) and a newly recognized unit at Buffalo, Scott County, Iowa (i.e. Andalusia Member; Witzke et al., 1985). As noted earlier Witzke And Bunker (1984) recognized a series of depositional cycles in

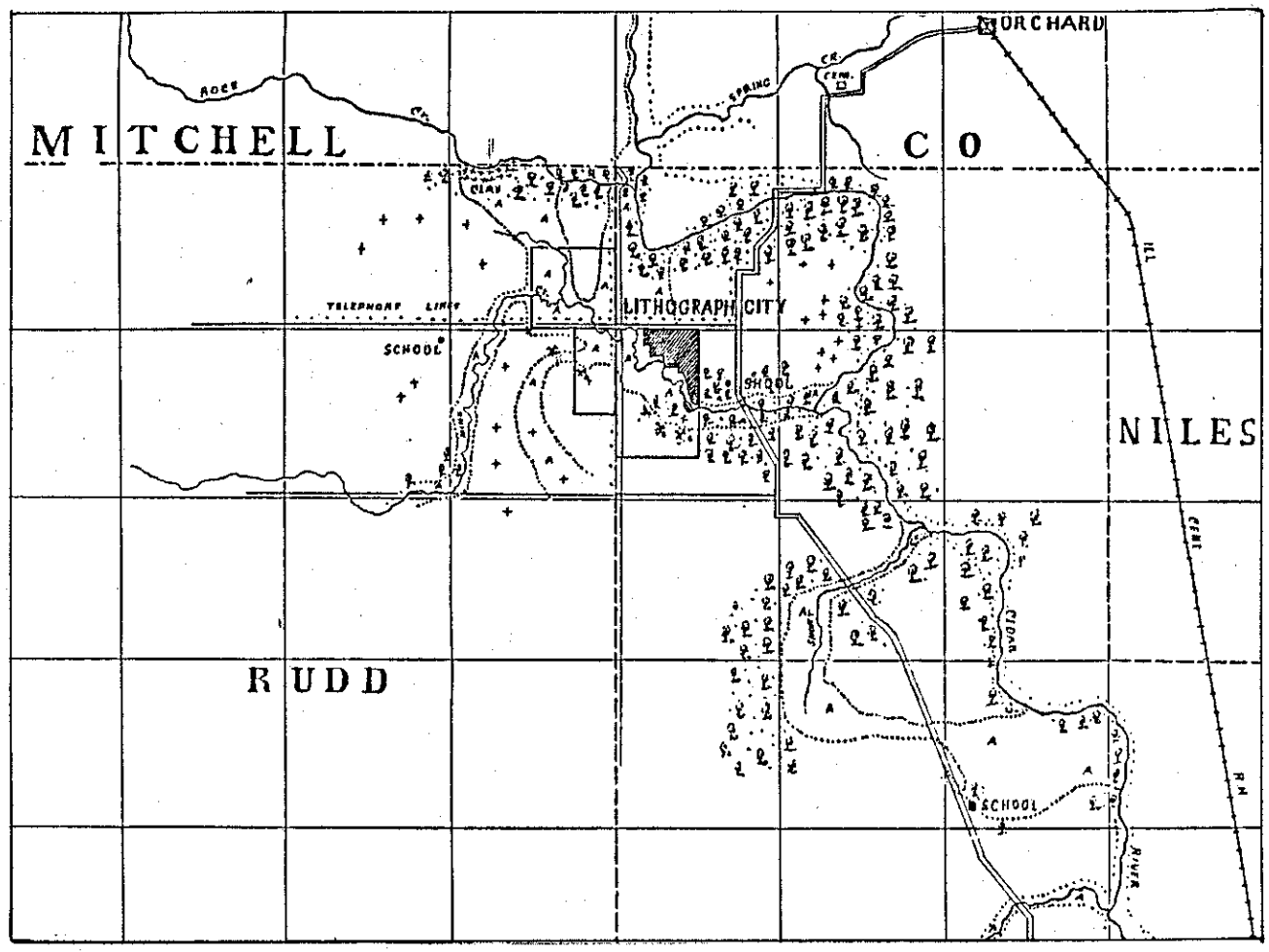

FIGURE 2. Map showing the historic location of Lithograph City in north-central Floyd County, Iowa (from Webster, 1915).

the Cedar Valley of northern Iowa, and it is within the context of a depositional cycle that the stratigraphic framework for Unit C (as modified by Witzke and Bunker, 1985) will be defined.

As mentioned earlier, Nelson (1939) and Stainbrook (1944) noted that the exposures along the Cedar River near Floyd, in northern Floyd County, when arranged in a vertical profile afforded the most complete section of the upper half of the Cedar Valley in northern Iowa. Nelson's proposal of a formal stratigraphic terminology was never adopted, but the area of his choice for the establishment of a terminology does offer a type area for defining a stratigraphic framework within the format of Witzke and Bunker's (1985) Unit C. Because of the preoccupation of Nelson's terminology the need for a series of useful and unique geographic terms was sought. Of particular interest was Webster's (1915) comments regarding the quarry operations for lithographic stone at Lithograph City in north-central Floyd County (Fig. 2). These

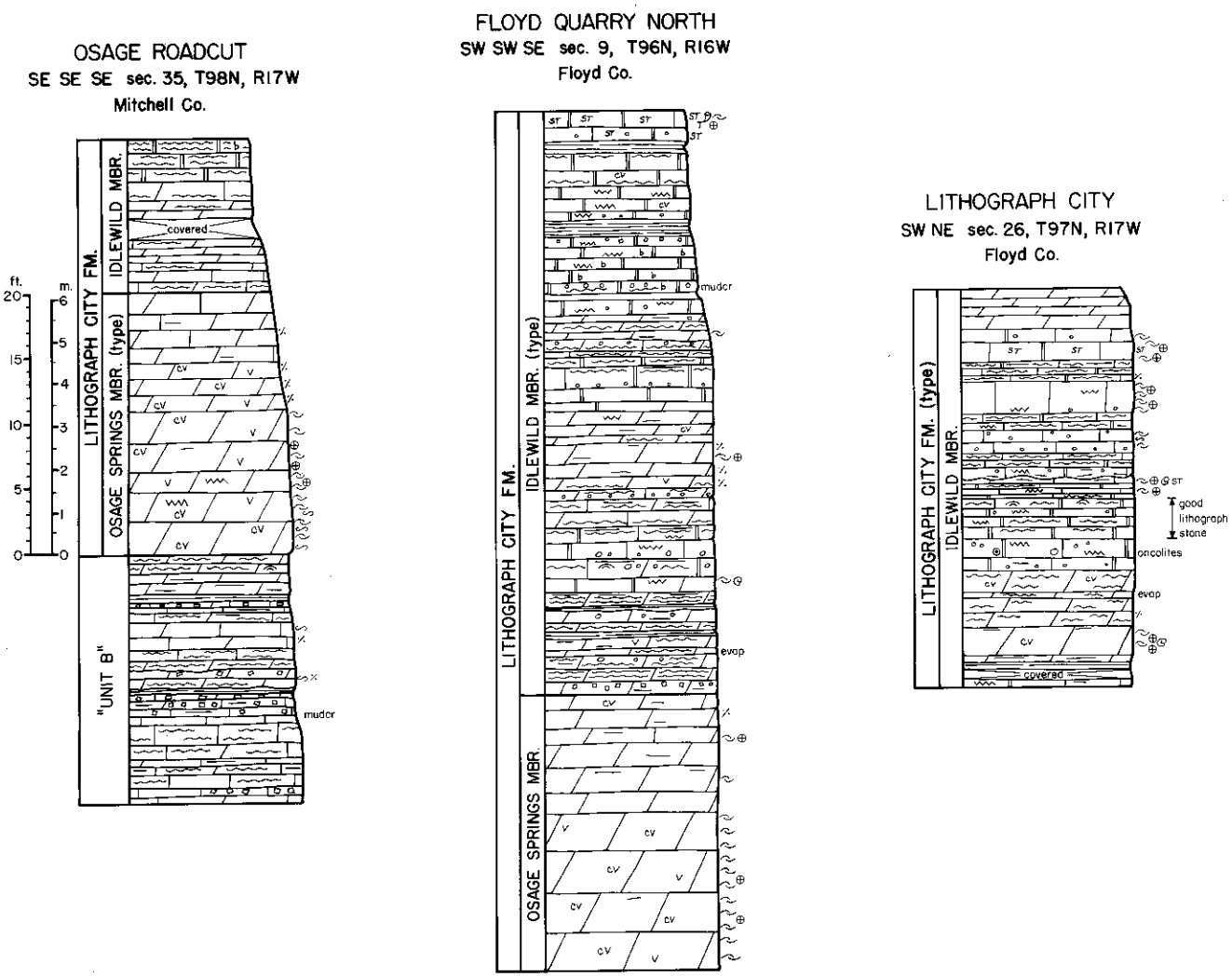

FIGURE 3. Stratigraphic sections from the type area of the Lithograph City Formation, with type sections of the Lithograph City Formation and the Osage Springs and Idlewild members. Lithologic key in Figure 4.

quarries were in operation for a short period in the early 1900's for the primary purpose of quarrying lithographic stone for Lithograph printing. Webster (1915) stated "In 1903, The Interstate Investment and Development Company submitted a sample of the cream-white lithographic stone from its quarries at Lithograph City, to the Iowa Publishing and Lithographing Company of Davenport, Iowa; and on this stone had quite an amount of engraving of the highest quality done. This firm recognized this stone to be equal in every respect to the best grade of German stone for the highest grade of lithographing. This stone was, by this firm, put on exhibition at the Louisana Purchase Exposition, St. Louis, in 1903; and here this stone and other products from the same quarries at Lithograph City, took ... several Awards and Medals ..." The onset of World I curtailed the importation of Bavarian stone, and the operation at Lithograph City was expanded to meet the hoped-for demand for quality lithograph stone. However, shortly after the Lithograph City operation expanded, the development of metal engraving largely eliminated the need for lithograph stone and the operation was short-lived. Because of the historical aspects of Lithograph City and the fact that the sections exposed at and near Lithograph City are contained within Witzke and Bunker's (1985) Unit C, the term Lithograph City is herein erected as a formation in substitution of the informal Unit C designation. Quarry sections are still available at the type locality at the former site of Lithograph City (SW NE Section 26, T97N, R17W, Floyd County; Fig. 3).

Unfortunately, no single exposure in northern Iowa displays the entire Lithograph City Formation, but a series of exposures in the Cedar River valley extending from the quarries north of Floyd to exposures south of Osage, Mitchell County, (a distance of approximately 9 miles) can be utilized as surface reference sections in the type area (Fig. 3). The most complete of the surface sections occurs at the Floyd Quarry (Fig. 3) and is considered a primary surface reference section for the Lithograph City Formation. The contact with the overlying Shell Rock Formation is not exposed within the type area, but can be seen at exposures to the south and west. The contact with the underlying "Unit B" of Witzke and Bunker (1984,1985) is exposed along County Road T38 where it crosses the Cedar River south of Osage, Mitchell County. Core penetrations of the Lithograph City Formation (Figs. 4 & 5) which contain the contacts with the overlying Shell Rock and underlying "Unit B" display the widespread nature of this unit in northern and central Iowa. These cores are reposited with the Iowa Geological Survey in Iowa City and are utilized as reference core sections for the Lithograph City Formation.

The Lithograph City Formation was deposited during a major transgressive -regressive depositional cycle (T-R IIb of Johnson et al., 1985). The lower transgressive part of the formation is characterized by vuggy fossiliferous dolomite and dolomitic limestones; whereas the upper regressive part is dominated by unfossiliferous laminated to intraclastic limestone and dolomite, with dense lithographic and sublithographic limestones locally prominent. Relatively thin fossiliferous limestones and dolomites also occur in the upper unit. The Lithograph City Formation varies in thickness from 80 to 100 feet across northern Iowa.

The Lithograph City Formation of north-central and central Iowa can be subdivided into three members, which include: the lower Osage Springs Member, the Thunder Woman Shale, and the upper Idlewild Member. Stratigraphic relationships of these three members are depicted in Figure 6. Two additional units from east-central and southeast Iowa, which share lateral facies relationships with the northern members, are also assigned member status within the Lithograph City Formation. These include, the State Quarry Member

(previously assigned member status within the Cedar Valley Formation; Bunker et al., 1985) of Johnson County, and the Andalusia Member ("Upper Dolomitic Unit" of Witzke et al. 1985) exposed in Scott and Muscatine counties. Fossiliferous strata of the Lithograph City Formation are characterized by conodonts (microfossils) of the Pandorinellina insita Fauna (Stauffer, 1940; Klug, 1982; Witzke and Bunker, 1984, 1985; Witzke et al., 1985) of Klapper et al. (1971). The Middle-Upper Devonian boundary falls at some undefineable point within the Lithograph City Formation.

OSAGE SPRINGS MEMBER. The basal transgressive marine unit of the Lithograph City Formation is herein termed the Osage Springs Member. It is named after Osage Springs County Park, located approximately 1 mile to the southwest of the town of Osage, Mitchell County. The type section of the Osage Springs Member (SE SE SE section 35, T98N, R17W; Fig. 3) is located at a roadcut (County Road T38) along the Cedar River 2.4 miles downstream from Osage Springs County Park. All the reference core sections (Figs. 4 & 5) contain the Osage Springs Member.

The Osage Springs Member is characterized by vuggy fossiliferous dolomite and dolomitic limestone. It locally contains coarsely crystalline calcite masses. Molds of brachiopods and crinoid debris commonly are noted. Skeletal limestones are present in the member in the field trip area, but are replaced by dolomitic facies over short distances. The member is dominated by dolomite in northern Floyd and Mitchell counties. Stromatoporoidal biostromes are developed locally, primarily in northwest Black Hawk, Butler, and southern Floyd counties. The Osage Springs Member varies in thickness from 16.1 to 20.5 feet (4.9-6.25 m) across north-central Iowa and thins to 11 feet (3.4 m) in central Iowa (Fig. 5).

THUNDER WOMAN SHALE. The upper regressive part of the Lithograph City Formation can be subdivided into two units. A prominent shale is locally present and is herein named the Thunder Woman Shale. It is named after Thunder Woman County Park, in the northeastern corner of Black Hawk County. The type section of the Thunder Woman Shale is located approximately 1 mile to the east of Thunder Woman County Park at Yokum Quarry (NW SW section 4, T90N, R14W, Black Hawk County; STOP 1). The Thunder Woman Shale is not regionally extensive, as noted by its absence in 3 of the 5 reference cores (Figs. 4 & 5). It is known in northern Black Hawk, Butler, and southern Floyd counties, and extends to the central Iowa Iowa subsurface (Webster County). This shale unit is not present to the north (northern Floyd and Mitchell counties) or south (Scott-Muscatine counties). The Thunder Woman Shale is a light gray dolomitic shale that varies in thickness from 10-20 feet (3-6 m) in its area of occurrence. Horizontal to subvertical burrows are common in the upper part of the member. The Thunder Woman Shale directly overlies the Osage Springs Member and shares lateral facies relationships with the lower part of the Idlewild Member (Fig. 4).

IDLEWILD MEMBER. The prominent regressive carbonate sequence in the upper Lithograph City Formation is herein termed the Idlewild Member. It is named after Idlewild State Park in north-central Floyd County. The Floyd Quarry (SW SW SE Section 9, T96N, R16W, Floyd County), which is located 1.4 miles downstream on the Cedar River from Idlewild State Park, is designated the type section. The contact with the overlying Shell Rock Formation is not exposed at the type section, but is represented in all the reference cores (Figs. 4 & 5) and can be seen at Stop 3.

The Idlewild Member forms the bedrock surface over large portions of Floyd, Mitchell, and Butler counties. It is dominated by unfossiliferous laminated to intraclastic limestone and dolomite. Mudcracked horizons are

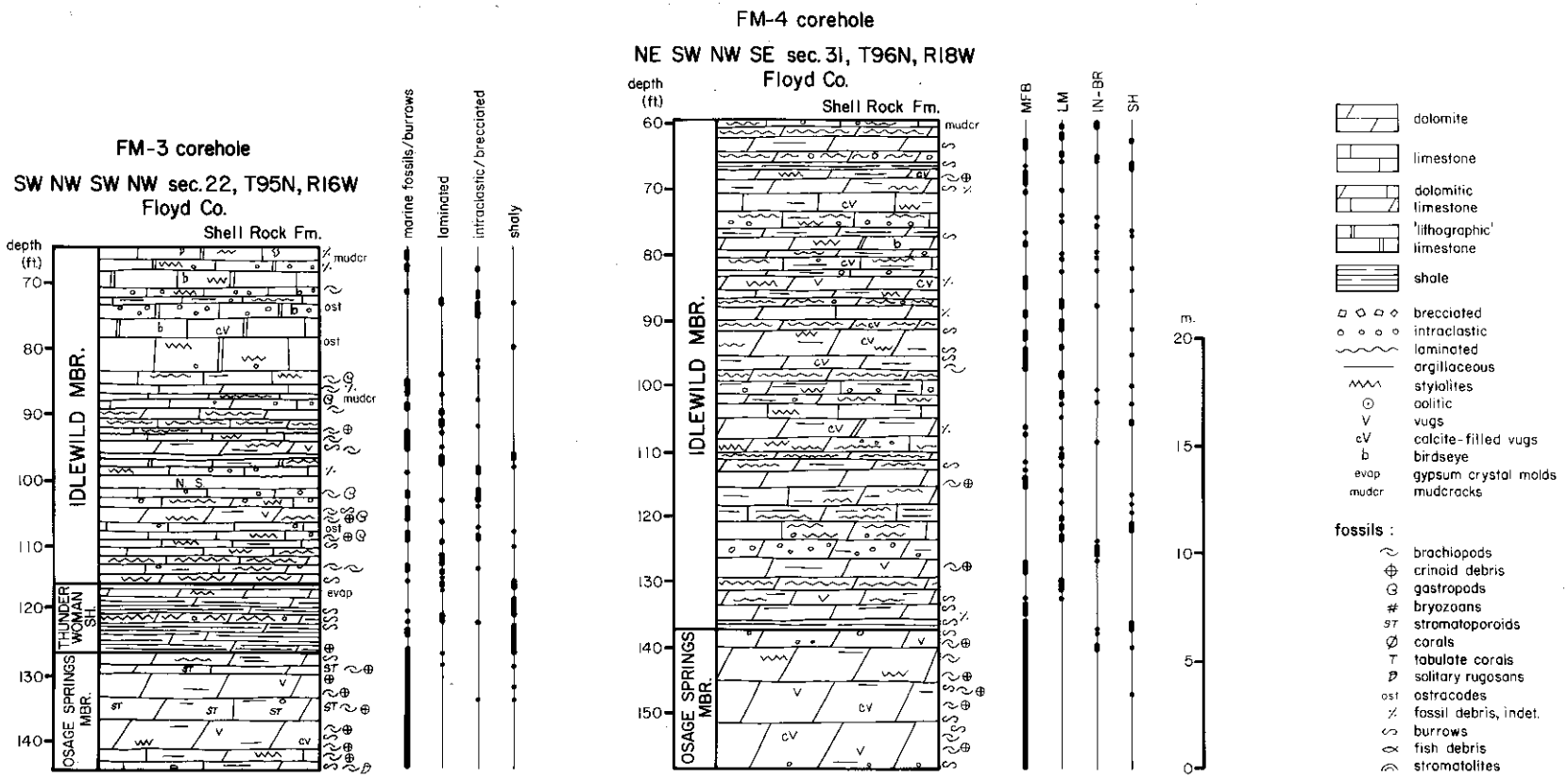

FIGURE 4. Two reference core sections of the Lithograph City Formation of north-central Iowa, with lithologic key. Cores reposited with the Iowa Geological Survey, Iowa City, Iowa.

common, and thin shales are present. Dense lithographic and sublithographic limestones (common at the Lithograph City quarries) are locally prominent, but are replaced laterally by dolomites and dolomitic limestones over relatively short distances (a few miles). Burrowed or fossiliferous beds intercalate with the laminated strata. Brachiopods and crinoid debris are noted in these beds, and stromatoporiod biostromes are locally noteworthy. Where capped by the Shell Rock, the Idlewild Member ranges in thickness from 52 to 79 feet (16-24 m) across north-central and central Iowa.

STATE QUARRY LIMESTONE MEMBER. Early definitions of the State Quarry Limestone considered it a separate formation distinct from the Cedar Valley. With the recognition of a new Cedar Valley stratigraphic framework in north-central Iowa (Witzke and Bunker, 1984) and the common occurrence of the Pandorinellina insita Fauna within the State Quarry and Unit C of Witzke and Bunker (1984), the State Quarry was reassigned as a member of the Cedar Valley Formation (Bunker et al., 1985). The elevation of Cedar Valley to group status and the recognition of a distinct formation, the Lithograph City, in the upper Cedar Valley necessitates some nomeclatural changes. Because the brachiopod and conodont faunas indicate correlation of the State Quarry with the northern section of the Lithograph City Formation, the State Quarry is assigned member status in that formation. The State Quarry unconformably overlies the Coralville and Rapid members of the Iowa Cedar Valley, and occupies erosional channels in the type area. The top of the State Quarry is erosionally truncated beneath Pennsylvanian and Quaternary strata. Strata equivalent to the upper Lithograph City Formation (Idlewild Member) are apparently absent in the type State Quarry area.

The State Quarry Limestone is dominated by skeletal calcarenites; packstones and grainstones contain varying proportions of echinoderm, brachiopod, branching stromatoporiod, and coral grains and intraclasts. Pelletal calcarenites and stromatoporoidal calcirudites also occur. Fish teeth and plates are common in the calcarenites in the lower and marginal parts of the State Quarry channels ("bone beds"). Skeletal calcilutites are interbedded with calcarenites near the channel margins. The State Quarry reaches thicknesses to about 40 feet (12 m). The old State Quarry northeast of North Liberty, Johnson County, is designated the type locality (SW SW NW SE section 8, T80N, R6W).

ANDALUSIA MEMBER. In 1985, Witzke et al. identified a new rock unit in the Scott-Muscatine counties area of east-central Iowa, which contained the Pandorinellina insita Fauna. They informally termed this interval the "Upper Dolomitic Unit" because of its prominent dolomitic nature, and separated it from the type Coralville Member where it had previously been assigned. The "Upper Dolomitic Unit" is herein termed the Andalusia Member (as suggested by Witzke et al., 1985). It is named after Andalusia Slough along the Mississippi River, in northwestern Rock Island County, Illinois. The type section is located approximately 1/2 mile to the north of Andalusia Slough at the Davenport Cement Company Quarry, Buffalo, Scott County, Iowa (NE NW NE section 33, T77N, R2E; a written description is included in Witzke et al., 1985). Previous assignment of the Andalusia Member (i.e. "Upper Dolomitic Unit" of Witzke et al., 1985) was as a member of the Cedar Valley Formation. However, because of nomenclatural changes regarding the elevation of the Cedar Valley to group status and the recognition of the Lithograph City as a distinct formation necessitate reassignment of the Andalusia. Because brachiopod and conodont faunas indicate correlation with the State Quarry and northern Iowa Lithograph City sections, the Andalusia Member is assigned member status in that formation.

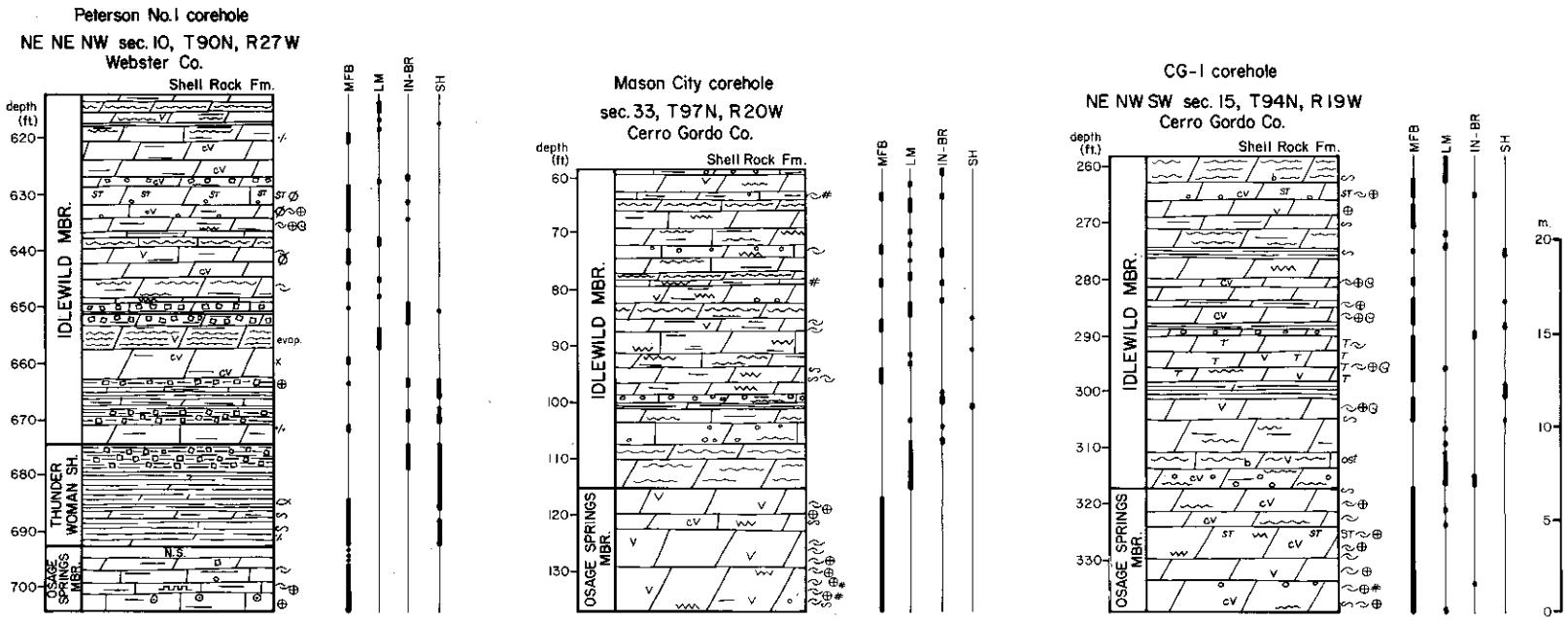

FIGURE 5. Additional reference cores sections. Lithologic key in Figure 4. Cores reposited with the Iowa Geological Survey, Iowa City, Iowa. Webster County section adapted from Klug (1982).

The Andalusia Member at its type section is 33 feet (10 m) thick, and is dominated by fossiliferous dolomites and dolomitic limestones; shales are common in the lower 12 feet (3.6 m). The Andalusia is an abundantly fossiliferous unit in comparison to its northern Iowa equivalents. It is fossiliferous throughout (except the basal 30 cm), with brachiopods, crinoids, bryozoans, gastropods, bivalves, rostroconchs, and natutiloids noted (Witzke et al., 1985). A prominent coral-stromatoporiod biostrome occurs in the upper part of the unit. Discontinuity surfaces or hardgrounds are locally developed.

CONODONT BIOSTRATIGRAPHY

The holotype of Pandorinellina insita was originally described from shaley partings found in the upper part of the Cedar Valley limestone, Hickok Quarry, Leroy, Minnesota (Stauffer, 1940). Stauffer, however, made no attempt at any further subdivision of the Cedar Valley. Later references to the exposures at Leroy assigned these rocks to the Coralville (Kohls, 1961; Mossler, 1978) based only upon lithologic similarities. Witzke and Bunker (1984) recognized the first occurrence of P. insita in the basal marine interval of Unit C (Osage Springs Member of the Lithograph City Formation) and proposed a general biostratigraphic framework for subdividing the Cedar Valley of northern Iowa. The occurrence of P. insita in the State Quarry and Andalusia members indicated correlation with Unit C strata (Lithograph City Formation) to the north (Witzke et al., 1985). The type locality of P. insita at Leroy, Minnesota, likewise correlates with the Idlewild Member in Iowa.

The Osage Springs and Idlewild members of the Lithograph City Formation of northern Iowa contain a restricted conodont fauna dominated by Pandorinellina insita. Upper Idlewild strata also contains rare Polygnathus sp. and a distinctive Pa element with a well-developed platform (perhaps a variation of P. insita). Sandberg and Poole (1977) regarded Pandorinellina insita as characteristic of a shallow-water biofacies equivalent to the Lowermost to Upper Polygnathus asymmetricus Zones. The oldest part of the insita Fauna, that characterized by the association of Pandorinellina insita and Polygnathus norrisi, can be correlated with the Lowermost asymmetricus Zone in the basinal-outer shelf conodont biofacies (Johnson et al., 1980, p. 97; Johnson et al. 1985, p. 568). An association of P. norrisi and Pandorinellina insita has been reported from the State Quarry Member in Johnson County (collection of Watson, 1974, p. I12, sample A-52; Witzke et al., 1985). The insita Fauna of the lower Andulusia Member is a low-diversity fauna comprised of Pandorinellina insita, Mehlina gradata, Icriodus subterminus, and a few indeterminate specimens of Polygnathus. Icriodus subterminus and Polygnathus sp., which are common to the Andulusia Member of southeast Iowa are conspicuously absent from the northern Iowa Lithograph City sections. Conodonts recovered from the uppermost Andulusia Member includes Ancyrodella rugosa, A. africana, A. alata (late form), Polygnathus asymmetricus, P. dubis, Icriodus subterminus, and Mehlina gradata (Witzke et al., 1985). The association of these three species of Ancyrodella within the upper Andalusia Member indicates a position very high within the Lower asymmetricus Zone (Klapper, 1985; Witzke et al., 1985). Unfortunately the northern Iowa Lithograph City sections are devoid of the upper Andalusia conodont association and, as such, zonal assignment based upon conodont biostratigraphy of the northern Iowa sections is not yet possible. However, comparative studies of the brachiopods within the Lithograph City

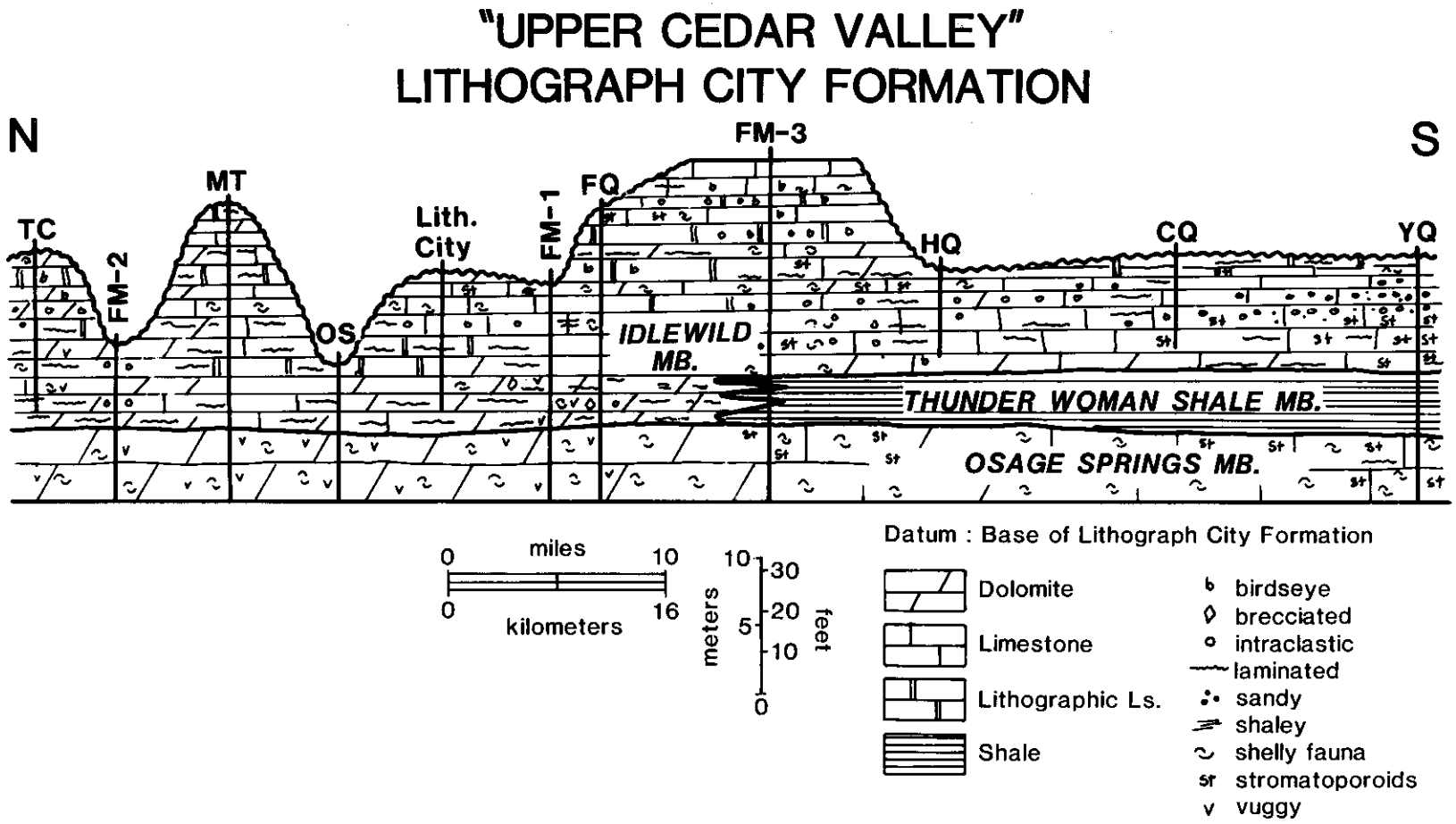

FIGURE 6. Cross-section illustrating the stratigraphic relationships of the three northern Iowa members of the Lithograph City Formation. Localities shown on Figure 2.

members does provide a possible avenue for regional correlations. In addition the overlying Mason City and Rock Grove members of the Shell Rock Formation contain conodonts of the Middle asymmetricus Zone (Anderson, 1966).

BRACHIOPOD FAUNA OF THE LITHOGRAPH CITY FORMATION OF NORTH-CENTRAL AND EASTERN IOWA
(discussion by Jed Day)

Introduction

The Lithograph City Formation contains a diverse and locally abundant marine invertebrate fauna with many assemblages dominated by brachiopods, and others by stromatoporoids or gastropods with brachiopods and echinoderms as accessory elements. This fauna is closely related to contemporaneous faunas in the western United States and Canada. Many of the species listed in Table 1 were widespread during latest Givetian and early Frasnian time and are found in the areas mentioned above. The distribution of brachiopod species within the Lithograph City Formation is summarized in Table 2. The occurrence of these species in the Devonian of Iowa is important with regard to latest Givetian and early Frasnian paleogeography and biostratigraphic correlations.

Strata of the Lithograph City Formation were deposited during a widespread eustatic sea-level rise and fall, equivalent to the Transgressive-Regressive Cycle IIb of Johnson et al. (1985), during Lowermost and Lower asymmetricus Zone time. Equivalent strata were deposited throughout tropical and subtropical Euramerica, although the brachiopod fauna of the Lithograph City Formation is most closely related to those found in carbonate strata of western North America. The distribution of many of these species suggests open marine seaway connections between these regions.

Much of the fauna is poorly known and/or in need of revision. The list in Table 1 represents the author's preliminary opinions as to the appropriate species nomens in terms of the current literature. Notably there are a number of new species of brachiopods belonging to the genera Cranaena, Strophodonta (Strophodonta), and Floweria. The new cranaenid is known only from the upper Andalusia Member; the new strophodontid occurs in both the upper Andalusia and Idlewild members; and the new davidsonid species of Floweria occurs in both the Idlewild and Osage Springs members in the type area of the Lithograph City Formation.

Previous Investigations

Many of the brachiopod taxa of this unit have been described by previous workers, who at the time considered these strata to be equivalant to the late Givetian type Cedar Valley units of the Johnson County area. The first species to be described were named by Hall (1858, Spirifer capax, p. 520; S. subattenuatus, p. 504; Strophodonta demissa, p. 495; and Atrypa reticularis, p. 515) from the upper Andalusia Member near Buffalo, Iowa. These are now known as Orthospirifer capax (Hall), Allanella annae (Stainbrook), Strophodonta (S.) iowensis (Stainbrook), and Variatrypa (R.) scutiformis (Stainbrook), see Tables 1 & 2.

Thomas and Stainbrook (1921, 1922) described Pugnoides solon (now Ladogioides solon (Thomas and Stainbrook)) from the State Quarry Member in

TABLE 1. Brachiopod fauna of the latest Givetian/early Frasnian Lithograph City Formation of north-central and eastern Iowa.

SPIRIFERIDA

Allanella allani (Warren)
A. annae (Stainbrook)
Eumetria? sp.
Orthospirifer capax (Hall)
Eleutherokomma jasperensis Warren
Eosyringothyris occidentalis Stainbrook
Desquamatia (*Independatrypa*) *independensis* (Webster)
Pseudoatrypa? *percrassa*? (Crickmay)
Spinatrypina cf. *S. augusticostata* Johnson & Trojan
Variatrypa (*Radiatrypa*) *rugatula* (Stainbrook & Ladd)
V. (*R.*) *scutiformis* (Stainbrook)
Athyris simplex Stainbrook & Ladd
A. vittata Hall
A. v. buffaloensis Stainbrook

STROPHOMENIDA

Strophodonta (*Strophodonta*) *iowensis* Stainbrook
S. (*S.*) n. sp.
Floweria altirostris (Stainbrook & Ladd)
F. n. sp.

ORTHIDA

Schizophoria lata Stainbrook
S. athabaskensis Norris

RHYNCHONELLIDA

Ladogioides solon (Thomas & Stainbrook)

PENTAMERIDA

Gypidula sp.

TEREBRATULIDA

Cranaena depressa Stainbrook & Ladd
C. sp. cf. *C. iowensis* Stainbrook
C. n. sp.

Johnson County. Stainbrook and Ladd (1924) described ten species of brachiopods from the State Quarry, which include: (1) Atrypa rugatula, (2) Cranaena depressa, (3) Composita simplex, (4) Cyrtina sp., (5) Eumetria sp., (6) Pugnoides solon Thomas and Stainbrook (1922), (7) Schizophoria striatula (Schlotheim), (8) Schuchertella altirostris, (9) Stropheodonta sp., and (10) Spirifer sp. In this report the specimens designated as Atrypa rugatula, in their Plate 1 figures 7 & 8 correspond to Variatrypa (R.) rugatula, the specimen shown as figure 9 is assigned to Spinatrypina augusticostata Johnson & Trojan. Ladogioides solon was also illustrated by Fenton and Fenton (1924, p.129, Pl. 25, figs. 9-12).

Watson (1974) reported a number of brachiopods from the State Quarry Member in east-central Iowa. Watson mentioned the occurrence of Spinatrypina sp., two species of Atrypa sp., "Spirifer" annae, Eleutherokomma sp., Parapugnax sp., and Eosyringothyris sp. cf. E. aspera Stainbrook. The species of atrypids mentioned by Watson correspond to: S. augusticostata, A. sp. 1=Variatrypa (R.) rugatula, A. sp. 2=V. (R.) scutiformis (Stainbrook); both "S." annae and Eleutherokomma sp. correspond to Allanella annae (Stainbrook); the State Quarry rhynchonellid Ladogioides solon was erroneously assigned to Parapugnax; E. aspera was misidentified, and is assigned to E. occidentalis Stainbrook, which is also known from the lower Andalusia Member in extreme eastern Iowa (Table 2). Norris (1983) placed Schizophoria strialtula in synonomy with S. athabaskensis, described from the Waterways Formation of Manitoba, Canada.

Stainbrook (1938, 1940, 1942, 1943) described many of the brachiopod species common in the lower Andalusia Member from Buffalo and Pine Creek in extreme east-central Iowa, which he erroneously assigned to the "waterlooensis zone" of the Rapid Member of the Cedar Valley. In 1938 he described Stropheodonta iowensis, S. prava, and Atrypa scutiformis from the "Stropheodonta iowensis" zonule of the "waterlooensis zone". Stropheodonta prava is considered as a synonym of S. iowensis, now known as Strophodonta (S.) iowensis (Stainbrook); the atrypid is now referred to as Variatrypa (Radiatrypa) scutiformis (Stainbrook). In addition he described Schizophoria lata (1940), Athyris vittata buffaloensis (1942), and the spiriferids (1943) Eosyringothyris occidentalis, Tylothyris annae, and Spinocyrtia capax(Hall). Tylothyris annae lacks a medial septum or myophragm in its pedicle valve and is considered one of the oldest species of the genus Allanella (A. annae (Stainbrook)). Subsequently Pitrat (1975) reassigned S. capax (Hall) to the genus Orthospirifer.

The fauna of the Osage Springs and Idlewild members in north-central Iowa contains many elements common to the State Quarry and Andalusia members to the south, and is largely undescribed (Tables 1 & 2). Charles Belanski made extensive collections of the Lithograph City faunas in the early part of this century and appeared to have been close to publishing on this important fauna prior to his death. Belanski clearly distinguished the Lithograph City strata and fauna from the type Cedar Valley and its faunas in east-central and southeastern Iowa, and referred to this unit as the Bloody Run Stage of the Cedar Valley. Subsequent Devonian workers in the western U. S. and Canada have described many genera and species of brachiopods that are now identified in the type area of the Lithograph City Formation of northern Iowa.

Fauna of the type Lithograph City Formation in north-central Iowa

Osage Springs Member

The basal Osage Springs Member contains a moderately diverse fauna whose composition is summarized in Table 2. Where assemblages predominately composed of brachiopods occur, commonly in association with stromatoporoids, Allanella, Variatrypa, and Athyris are the dominant taxa. At Yokum Quarry (locality YQ, Figure 1; Stop 1), Athyris vittata occurs in skeletal mudstones low in the Osage Springs, with diverse and abundant assemblages occurring in biostromal units in the upper portion of the member at this locality. The upper biostromal units at Yokum Quarry contain Allanella allani, Desquamatia (Independatrypa) independensis, Athyris vittata, Strophodonta (S.) iowensis, and Variatrypa (Radiatrypa) scutiformis.

South of Charles City at the Charles City South Quarry, biostromal units of the Osage Springs contain assemblages, that include: Allanella allani, Athyris vittata, and Variatrypa (R.) scutiformis.

Idlewild Member

Brachiopods occur in low diversity brachiopod-dominated, as well as in stromatoporoid-dominated biostromal assemblages, with echinoderm debris variably absent or present in Idlewild Member assemblages. At Yokum Quarry no brachiopods are known from either the Thunder Woman Shale or Idlewild Members. At other localities in Butler, Bremer, and Floyd counties Idlewild brachiopod assemblages are common in skeletal packstones, wackestones, mudstones, and biostromal baffle and framestones.

At Hanneman Quarry in southern Floyd County (locality HQ, Figure 1) abundant brachiopods weather from biostromal bafflestones that include: Allanella allani, Composita vittata, Cranaena sp. cf. C. iowensis, Floweria n. sp., Strophodonta (S.) n. sp., Variatrypa (R.) scutiformis, Pseudoatrypa? percrassa?, and Gypidula sp. At the Lubben Quarry (locality LQ, Figure 1; Stop 2) assemblages are dominated by Allanella, Composita, and Variatrypa. At the Aureola Hills locality (locality AH, Figure 1; Stop 3) assemblages are dominated by Allanella allani with Athyris vittata locally abundant in various units.

Eleutherokomma jasperensis is known from the collections of Charles Belanski from samples in the upper 2.5 meters of the Idlewild Member in old roadcut localities near the Aureola Hills locality, and in the uppermost Idlewild exposed in localities south of Nora Springs in Cerro Gordo County that Belanski visited in the 1920's. The authors have not yet recovered E. jasperensis in our collections from the upper Idlewild Member. The composition of upper Idlewild brachiopod assemblages in shown in Table 2. The occurrence of this species in the upper Idlewild is important with regard to correlation of these strata with the Canadian Devonian strata in Alberta and Manitoba.

Fauna of the Lithograph City Formation in east-central and eastern Iowa

State Quarry Member in the Johnson County area

Brachiopods occur in nearly all lithologies of the State Quarry Member

Species \ Member	Osage Springs	Idlewild		State Quarry	Andalusia	
		lower	upper		lower	upper
Allanella allani ☞	+	+	+			
A. annae ☞				+	+	
Eumetria sp.				+		
Eleutherokomma jasperensis ☞			+			
Eosyringothyris occidentalis				+	+	
Orthospirifer capax						+
Desquamatia (I.) independensis	+					
Pseudoatrypa? percrassa?		+				
Spinatrypina augusticostata ☞				+		
Variatrypa (R.) rugatula				+		
V. (R.) scutiformis ☞	+	+	+	+	+	+
Athyris simplex				+		
A. vittata	+	+	+		+	
A. v. buffaloensis					+	
Floweria altirostris				+		
F. n. sp.	+	+	+			
Strophodonta (S.) iowensis ☞	+			+	+	
S. (S.) n. sp.		+				+
Schizophoria lata ☞	+				+	
S. athabaskensis				+		
Ladogioides solon ☞				+		
Gypidula sp.		+				
Cranaena depressa				+		
C. sp. cf. C. iowensis		+				
C. n. sp.						+

☞ :Biostratigraphically important species

TABLE 2. Distribution of brachiopods within the Lithograph City Formation.

where it is known to outcrop in the Johnson County region. Channel-fill skeletal grainstones exposed at the type locality (Old State Capitol Quarry) contain assemblages dominated by Variatyrpa (R.) rugatula, Craneana depressa, Ladogioides solon, with minor occurrences of Schizophoria athabaskensis, Floweria altirostris, and Allanella annae. Stainbrook and Ladd (1924) recorded the occurrence of Eumetria sp.; this is a rare species known only from the type locality.

Skeletal grainstones overlying the Coralville Member of the Cedar Valley at Mehaffey Bridge contain a similar assemblage, although skeletal wackestones capping the section at this locality contain an assemblage composed exclusively of V. (R.) scutiformis. Spinatrypina occurs in assemblages dominated by either Allanella or gastropods and amphiporid stromatoporoids in skeletal packstones at State Quarry exposures on the west side of Coralville Lake southwest of Mehaffey Bridge.

At Meyers Quarry southwest of Solon Allanella annae and Variatrypa (R.) rugatula occur in the lower skeletal rich grainstones, and V. (R.) scutiformis in the upper mudstones of the State Quarry (Watson,1974). Just to the south at the Vanourney Quarry Eosyringothyris occidentalis was reported from skeletal packstones, although no precise stratigraphic locality was mentioned in Watson's (1974, p. 85) discussion.

Andalusia Member of extreme eastern Iowa

The Andalusia Member is informally divided into two units, these are: the "lower" and "upper" Andalusia Member, with each containing distinctive faunas. The former fauna is closely related to those of the State Quarry and Osage Springs members, and the second to the Idlewild Member fauna of the type Lithograph City Formation of north-central Iowa. The Andalusia Member is best exposed at the Davenport Cement Co. Quarry in Buffalo Iowa, referred to as the "Upper Dolomitic Unit" by Witzke et al. (1985). In addition, Hall (1858) and Stainbrook (1938, 1940, 1942, 1943) collected brachiopods from both the "lower" and "upper" Andalusia Member at exposures near Buffalo and along Pine Creek to the east along the Mississippi River.

"Lower" Andalusia Fauna. At the Davenport Cement Co. Quarry in Buffalo, Iowa, the lower Andalusia Member contains a moderately diverse and very abundant brachiopod fauna. Assemblages are dominated by Strophodonta (S.) iowensis, Variatrypa (R.) scutiformis, and Schizophoria lata; with Composita vittata, Allanella annae, and Eosyringothyris occidentalis occuring as minor elements in these assemblages, present in shales and argillaceous skeletal packstones. Hall (1858) and Stainbrook (1938, 1940, 1942, 1943) described almost all of the "lower" Andalusia taxa from the lower shaley units (units 29 & 32 of Witzke et al., 1985), which he referred to as the "Stropheodonta iowensis zonule".

"Upper" Andalusia Fauna. The upper thick-bedded and massive dolomites and shaley biostromal units contain a low-diversity brachiopod fauna, although here low diversity is due to the difficulty in recovering fossil specimens from the dolomites. These are the units from which both Hall and Stainbrook collected Orthospirifer capax. In addition Strophodonta (S.) n. sp., Cranaena n. sp., and large specimens of Variatrypa (R.) scutiformis have been collected by the author from these strata. Notably the stromatoporoid and coralline biostrome units at the Davenport Cement Co. Quarry contain gastropods, and the only rugose coral fauna known from the Lithograph City Formation.

Regional and inter-regional correlation of the Lithograph City Formation based upon brachiopods

Regional Correlation

Lower Lithograph City Formation. The Osage Springs Member of the type area of the Lithograph City Formation is clearly related in age to the State Quarry, and "lower" Andalusia members through the shared occurrences of certain stratigraphically important taxa. The occurrence of Strophodonta (S.) iowensis and Variatrypa (R.) scutiformis (Table 2) in all three members provides a basis for the regional correlation of these units. In addition the shared occurrences of Allanella annae and Eosyringothyris occidentalis (Table 2) in State Quarry and "lower" Andalusia strata allows direct correlation between these units in eastern Iowa.

These three members represent facies deposited during the initial onlap phase of Lithograph City sedimentation in Iowa. The occurrence of the aforementioned brachiopod species in conjunction with the conodonts Pandorinellina insita and Polygnathus norrisi (Watson, 1974; Witzke et. al., 1985) clearly indicate assignment of these strata to the Lowermost asymmetricus Zone.

Upper Lithograph City Formation. The strata of both the Idlewild and "upper" Andalusia members contain the thick shelled Strophodonta (S.) n. sp. which allows a tentative correlation between these units. The occurrence of Allanella allani throughout, and Eleutherokomma jasperensis in the upper Idlewild Member suggests assignment of these strata to the Lower asymmetricus Zone. The occurrence of A. allani in Iowa appears to be its oldest known occurrence. Elsewhere it is known from strata assigned to the Middle asymmetricus Zone (i. e. Nevada and Alberta).

The occurrence of species of the conodont genus Ancryodella high in the "upper" Andalusia Member allows assignment of the uppermost Andalusia to the Lower asymmetricus Zone. At this time the "upper" Andalusia Member fauna is poorly known. Subsequent investigation may yield more biostratigraphically significant species of both conodonts and brachiopods.

Inter-regional Correlation

The faunas of the members of the the "lower" and "upper" Lithograph City Formation can be correlated with other well known faunas from Nevada and western Canada. Conodonts provide biostratigraphic control for correlation of the "lower" lithograph City strata, whereas brachiopods appear to provide a more accurate means of correlation, especially for the Idlewild Member fauna.

Nevada. Ladogioides pax, Allanella layeri, Variatrypa (R.) klukasi, and Spinatrypina augusticostata occur with the conodont Pandorenellina insita in strata in the Antelope Range of central Nevada, and are assigned to the upper disparilis Zone (=Lower dengerli Zone of Johnson et. al., 1980) and by Johnson & Trojan (1982), which is considered equivalent to the Lowermost asymmetricus Zone (Klapper & Zeigler, 1982). In terms of their faunal intervals, the Osage Springs, State Quarry, and "lower" Andalusia Member faunas are correlated with Faunal Interval 28 (Upper Tecnocyrtina fauna) of Johnson & Trojan (1982). The species mentioned above are closely comparable or identicle with those that occur in the "lower" Lithograph City Formation of Iowa, namely: L. solon, A. annae, V. (R.) scutiformis, and S. augusticostata.

The "upper" Lithograph City faunas are not as easily correlated with the Nevada section. The occurrence of Allanella allani in the "lower" and "upper" Lithograph City strata appears to be the oldest known occurrence of this species in Euramerica. This species ranges upward into the Mason City and Nora members of the Shell Rock Formation.

It appears that A. allani migrated from the Iowa carbonate platform habitats into western North America during the marine onlap phase of T-R cycle II-c (Johnson et. al., 1985), represented in Iowa by the Mason City Member of the Shell Rock Formation. In Nevada, Johnson, et. al. (1980) reported this species in association with conodonts assigned to the Middle asymmetricus Zone, and is the major element of the Allanella fauna of Faunal Interval 29.

Western Canada. The faunas of both the "lower" and "upper" Lithograph City Formation are correlable with those known in equivalent strata in Manitoba, Saskatchewan, and Alberta.

Manitoba-Saskatchewan. Strata of the Lithograph City Formation correlate with P. insita bearing units in the Elk Point Basin of southwest Manitoba and Saskatchewan. The fauna of the "Micritic Limestone beds" of the Point Wilkens Member of the Souris River Formation in the Lake Winnipegosis-Lake Manitoba region includes: V. (R.) clarkei, D. (I.) independensis, Allanella allani, Cranaena iowensis, Athyris vittata, and Eleutherokomma sp. (Norris, Uyeno & McCabe, 1982). In Saskatchewan, Unit B of the Davidson Member of the Souris River Formation contains V. (R.) clarkei, D. (I.) independensis, Allanella allani, Athyris vittata, and Schizophoria sp.(Norris, Uyeno & McCabe, 1982). At this time no species characteristic of "upper" Lithograph City Formation strata are known from units in this region (i.e. E. jasperensis).

Alberta. Species characteristic of both "lower" and "upper" Lithograph City Formation strata are known from units in Alberta. Norris & Uyeno (1983) reported Ladogioides pax, V. (R.) klukasi, Schizophoria lata, Tecnocyrtina billingsi, and Eleutherokomma impennis from the Peace Point Member of the Waterways Formation in the Gypsum Cliffs area of Northeastern Alberta. Nearly all of these species are closely comparable to those found in "lower" Lithograph City strata, with the exception of T. billingsi. At this time there are no species of Tecnocyrtina known from Lithograph City Formation strata in Iowa, although T. curvilineata (Stainbrook) occurs in the upper Rapid Member in the Johnson County area (Stainbrook, 1943; Johnson & Trojan, 1982).

Norris and Uyeno (1981) reported faunas of Lowermost and Lower asymmetricus Zone age from the Waterways Formation in the Birch River and Powell Creek area of the District of Mackenzie in northeastern Alberta. The "lower" Lithograph City Formation fauna is correlated with that of Units I, II, and III of the Calumet Member (figure 3, p. 10, Norris and Uyeno, 1981). This unit contains Ladogioides asmenista, V. (R.) clarkei, Spinatrypina sp., Athyris parvula, Allanella minutilla, and Schizophoria lata that are comparable to species in the State Quarry and "lower" Andalusia members of Iowa. The "upper" Lithograph City Formation is correlated with Unit IV based upon the shared occurrence of Eleutherokomma jasperensis.

At this time the "lower" Lithograph City fauna can be correlated with the middle and upper parts of the Calumet Member of the Waterways Formation of the Clearwater rivers area of Northeastern Alberta. This correlation is based upon the occurrence of Schizophoria lata, S. athabaskensis, and Strophodonta (S.) albertensis (Norris, 1983) in the Calumet Member. These species are

closely comparable or identical to those found in the Osage Springs, State Quarry, and "lower" Andalusia members of the Lithograph City Formation.

DEPOSITIONAL ENVIRONMENTS

The main features of a Cedar Valley carbonate depositional cycle include: (1) the base of the cycle typically is flat, (2) the basal transgressive unit is thin in comparison to the overall depositional cycle thickness, and (3) the main sediment thickness in the depositional wedge is developed upward and progradationally. The depositional cycle is completed with the progradation of supratidal sediments to the shelf-edge accompanying a drop in sea level. The shelf is subaerially exposed as the seas withdrew to the southeast, prior to the beginning of a new depositional cycle. A more comprehensive model of sedimentation involves complex patterns of facies produced by an interplay of topography, and biologic and physical forces. A "facies model" or generalized framework of carbonate environments has four main topographic elements -- the carbonate land, shelf, slope, and basin. The shelf may be very broad or narrow, and have a pronounced edge where tidal currents, waves, and biologic activity are all active. A more complete approach to evaluating carbonate rock sequences combines recurrent transgressive-regressive cycles with the sedimentary framework.

Beginning with a stripped carbonate terrain as a topographic base (uppermost Coralville, Fig. 7 A), a clear tropical Lithograph City sea transgresses the area (State Quarry - lowermost Andulusia members represent the initial onlap, Fig. 7 B). Transgression proceeds to a point where sea level reaches maximum onlap (Osage - Andulusia members represent maximum transgression, Fig. 7 C). Muds accumulated on the slope and in the basin, while deposits of skeletal sands and biostromes built up to sea level on the crest of the former shelf-edge. Farther back on the shelf, prograding tidal flats begin to fill the lagoon (Idlewild Member, Fig. 7 D). The sequence of "cyclic" facies in vertical section locally depends on the influence of environmental factors, cyclic transgression-regression, and exposure during low sea level stands.

The cyclic approach to interpretation of vertical rock sequences has proven a rapid, useful method of sorting complex geological facts into a meaningful sedimentary framework (Coogan, 1972). Further refinement or a strenuous attempt to fit rocks to cyclic models forces recognition of irregularity and randomness of events resulting from the interplay of physical and biological forces on an inherited topographic base. Irregularity and randomness negate the strictly cyclic nature of sequential events and reduce their predictability. A combination of the cyclic and facies models has provided a more substantial base for interpretation of the Iowa Cedar Valley Group.

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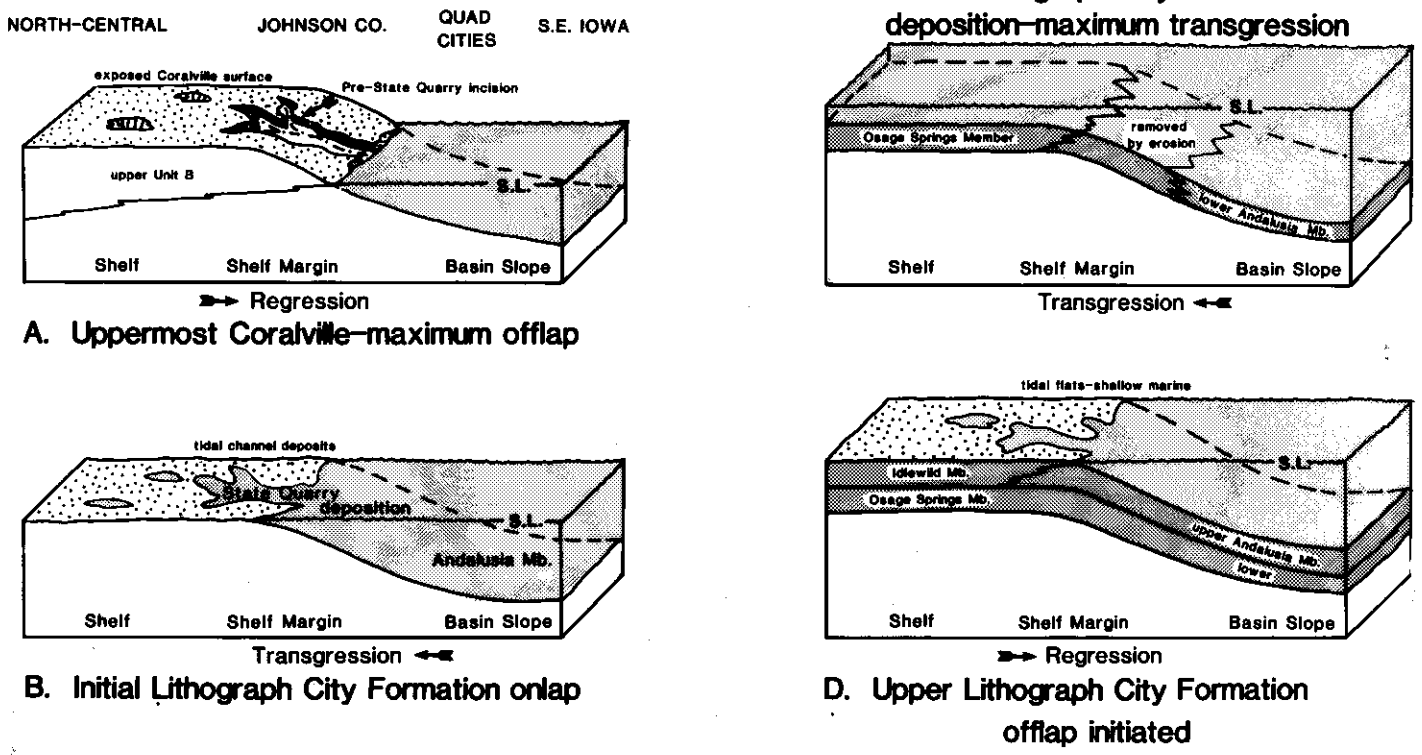

FIGURE 7. Generalized block-diagrams illustrating interpreted depositional relationships of the Lithograph City Formation between north-central Iowa (Osage Springs and Idlewild members) and southeast Iowa (State Quarry and Andalusia members).

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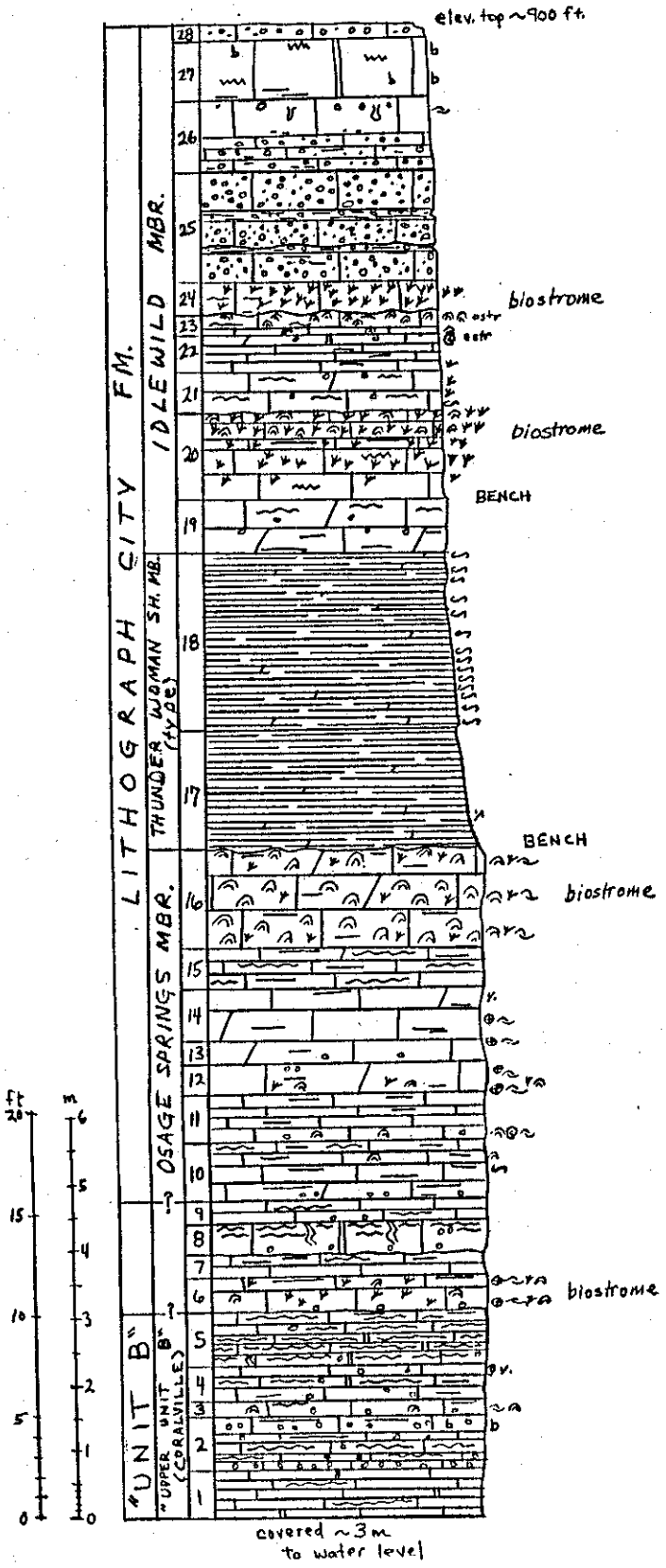
NOTES

STOP DESCRIPTIONS AND DISCUSSIONS



STOP 1. Yokum Quarry, composite section, near Finchford - NW SW section 4, T90N, R14W; Black Hawk County. Lithologic Key in Figures 4 & 6, and Stop 2.

STOP 1 - YOKUM QUARRY SECTION - Owned by Basic Materials Corporation (section measured by B.J. Witzke, B.J. Bunker, and J. Day, Iowa Geological Survey, 1985)

LOCATION - NW SW Section 4, T90N, R14W; Black Hawk County; elevation of the top of quarry section is approximately 900′ (sea level datum)

MIDDLE and UPPER DEVONIAN
CEDAR VALLEY GROUP
LITHOGRAPH CITY FORMATION

IDLEWILD MEMBER

UNIT 28 - Limestone, small intraclastic unit, with scattered to rare sand; 20 cm.

UNIT 27 - Limestone, very fine to sublithographic, argillaceous, shaley near base, stylolitic, birdseye and stromatactis structures (1-2 mm) throughout; 90 cm.

UNIT 26 - Limestone, very fine to extremely fine, slightly argillaceous, dense; thin argillaceous partings in lower half, with small scattered intraclasts (< 1 mm), scattered to abundant fine to medium quartz sand; upper part includes scattered sand, calcite-replaced brachiopods (spiriferids ?), stromatactis structures near top; 1.1 m.

UNIT 25 - Limestone, prominent intraclastic unit, part slightly argillaceous, scattered to abundant intraclasts (< 1 mm to 5 cm in size), scattered to abundant fine to medium quartz sand; approximately 45 cm above base occurs a prominent 7-13 cm shale, calcareous, chunky, laterally includes intraclastic lenses, pebbles, slightly sandy; approximately 98 cm above base another prominent shale (18 cm), calcareous, chunky, with scattered intraclasts, sandy; a 3-5 cm shale at top of unit; 1.76 m.

UNIT 24 - Limestone, biostrome, slightly dolomitic; abundant branching stromatoporoids (1-3 mm diameter), massive stromatoporoids in lower part; upper 10 cm laterally loses stromatoporoids to become replaced by dense limestone, very faintly laminated; 49 cm.

UNIT 23 - Limestone, biostrome, abundant ostracods in lower half, in part finely laminated, scattered to abundant stromatoporoids in upper part (to 4 cm diameter), part shaley; 22 cm.

UNIT 22 - Limestone, very fine to sublithographic, dolomitic, small scattered intraclasts; scattered small branching stromatoporoids, small irregular stromatoporoids to 3 cm, ostracods, and gastropods; 67 cm.

UNIT 21 - Limestone, very fine to extremely fine, burrowed at base, small intraclasts scattered, very faintly laminated in uppermost part; scattered small branching stromatoporoids; 56 cm.

UNIT 20 - Limestone, very fine to extremely fine, biostrome, stylolitic, dense, part argillaceous; scattered to abundant branching stromatoporoids (1-2 mm diameter), common small hemispherical stromatoporoids (2-10 cm) in upper 40 cm; uppermost part massive stromatoporoids; 1.29 m.

UNIT 19 - Dolomite to calcareous dolomite, very fine to extremely fine, slightly argillaceous; upper part dense, faintly laminated; 85 cm.

THUNDER WOMAN SHALE MEMBER (type section)

UNIT 18 - Shale, slightly dolomitic, light - light medium gray, chunky, scattered to numerous horizontal to subvertical burrows; 2.7 m.

UNIT 17 - Shale, slightly dolomitic, light - light medium gray, chunky, slightly flakier and softer in top 69 cm, crumbly; 1.78 m.

OSAGE SPRINGS MEMBER

UNIT 16 - Limestone, dolomitic, biostrome, matrix of biostrome very argillaceous to shaley, becoming shalier upwards through unit; hemispherical and laminar stromatoporoids (5 - 20 cm) common, branching stromatoropoids, atrypids, spiriferids, and other brachiopods; top of biostrome exhibits a hummocky surface which is displayed at the top of the first bench on the west side of the quarry; 1.20-1.62 m.

UNIT 15 - Limestone, extremely fine, dolomitic, dense, thin to flaggy bedded, slightly argillaceous to argillaceous, shaley in upper part, finely laminated (1-5 mm); cliff former; 61 cm.

UNIT 14 - Limestone, very fine to extremely fine, dolomitic, dense, slightly argillaceous, slightly nodular in upper half; some skeletal lenses scattered which includes: crinoid debris, spiriferids, and other brachiopods; 78 cm.

UNIT 13 - Limestone, very fine to extremely fine, dense, some intraclastic lenses, shaley at top,; spiriferids, and crinoid debris noted near top; 35 cm.

UNIT 12 - Limestone, skeletal packstone, crinoid debris, hemispherical stromatoporoids (to 4 cm diameter), digitate stromatoporoids, gastropods, spiriferids, and other small brachiopods; 48 cm.

UNIT 11 - Limestone, fine to extremely fine, skeletal wackestone to packstone in lower 1/3, small hemispherical stromatoporoids (to 5 cm diameter) common, small gastropods, spiriferids; flat pebble intraclasts (to 3 cm) scattered throughout; upper 2/3's, Limestone, very fine to extremely fine, slightly argillaceous to shaley, forms recessive unit; 71 cm.

UNIT 10 - Limestone, extremely fine to sublithographic, dolomitic in part, dense to massive, argillaceous, thinly bedded, shaley; intraclastic at base (clasts 1 - 8 mm); burrowed in upper half; middle

part contains large hemispherical stromatoporoids (to 9 cm in diameter); isolated thin shale part at top; 87 cm.

MIDDLE DEVONIAN
CEDAR VALLEY GROUP
"UPPER UNIT B"
(CORALVILLE)

UNIT 9 - Limestone, fine to extremely fine, dense, intraclastic (0.5-15 mm), faintly laminated; 35 cm.

UNIT 8 - Limestone, very fine to sublithographic, massive, in part fractured (some shale filled), intraclastic at base (1 mm-1 cm) with indeterminate elongate molds to 5 mm; becomes faintly laminated with small intraclast (small - medium sand size) molds (skeletal ?) in middle part; upper half dense, faintly laminated, with a few small intraclasts; 48 cm.

UNIT 7 - Limestone, very fine, dense, very shaley to platy in top half, laminated; irregular surface at top (3 cm relief) with prominent irregular shale (0-6 cm) at contact; 34 cm.

UNIT 6 - Limestone, biostrome, massive, highly fractured; intraclastic at base (to 3 cm); scattered skeletal material including: crinoid debris, brachiopods (including spiriferids and Athyris), laminar stromatoporoids, Amphipora, and gastropods; 54 cm.

UNIT 5 - Limestone, extremely fine to sublithographic, dense throughout, faintly laminated, in part intraclastic (to 2 cm); scattered lenses of microbreccia in lower part; scattered shale partings throughout; upper part laminated interval which shows local thickening with amplitudes of 2 cm (stromalites ?); shaley at top; 79 cm.

UNIT 4 - Limestone, very fine to sublithographic, dense; lower 13 cm shaley in part and irregularly bedded; faintly laminated in middle portion of unit, small intraclasts scattered throughout; small gastropods and other indeterminate skeletal debris near top; laterally discontinuous shale part at top; 55 cm.

UNIT 3 - Limestone, fine to extremely fine, massive, scattered intraclasts (1-10 mm), upper 6-10 cm dense and faintly laminated, shaley at top; scattered indeterminate brachiopods, few scattered rounded stromatoporoids (to 4 cm in diameter); shale part at top; 27 cm.

UNIT 2 - Limestone, extremely fine to sublithographic at top, fine to extremely fine below, dense throughout; near top scattered calcite spar resembling birdseye grading to intraclastic faintly laminated beds below, clasts medium to coarse sand size with larger clasts to 5 cm; 4 cm shale at top; 83 cm.

UNIT 1 - Limestone, extremely fine to sublithographic, dense, very faintly laminated in part; 68 cm.

STOP 1. YOKUM QUARRY near Finchford

Discussion. (PLEASE USE CAUTION WITHIN THE QUARRY AREA. HARDHATS ARE REQUIRED.) It has been a number of years since the last field trip to Yokum Quarry (Anderson, 1972a,b). Although the descriptive portion and the interpretation of the depositional environments are similiar, the stratigraphic placement of the Yokum Quarry section is viewed within the context of the newly defined Lithograph City Formation.

Of particular interest in the quarry is the pronounced west-southwest dip of the section. From Janesville, 2.7 miles to the east, to Yokum Quarry we have moved up section approximately 200 feet (61 m). This significant rise in section in combination with the observed dip in the quarry, attests to a prominent north-south structure in the Yokum Quarry area. Further work is needed to clarify and define the nature of this structure (i.e. fault, fold, or flexure).

The basal contact of the Lithograph City Formation has been arbitrarily drawn at the bottom of unit 10, primarily based upon the change in character from laminated lithographic and intraclastic unfossiliferous limestones below to fossiliferous limestones above. The fossiliferous interval above (primarily units 11-14, 16) contains the conodont Pandorinellina insita and a brachiopod fauna characteristic of the Lithograph City Formation to the north. However, the recovery of P. insita from unit 6 (a biostromal unit noted in the northeastmost quarry wall) may necessitate moving the base of the Lithograph City Formation down to the base of unit 6. The inclusion of laminated lithographic and intraclastic limestones in the basal Osage Springs Member, however, is generally inconsistent with observations to the north and west where it is a prominent fossiliferous unit; although laminated limestones are noted in unit 15. Alternatively, the inclusion of unit 6 with upper "Unit B" strata (which equates with the Coralville Member) also poses a potential problem, since the first occurrence of P. insita would then fall within the upper regressive portion of "Unit B," instead of within the basal transgressive portion (Osage Springs-Andalusia) of the Lithograph City Formation as noted elsewhere in Iowa. However, facies relationships within the Osage Springs Member to the south and southwest are not known. Likewise, the vertical stratigraphy below the quarry floor is also unknown, which could in part help clarify the contact relationships between "Unit B" and the Lithograph City Formation.

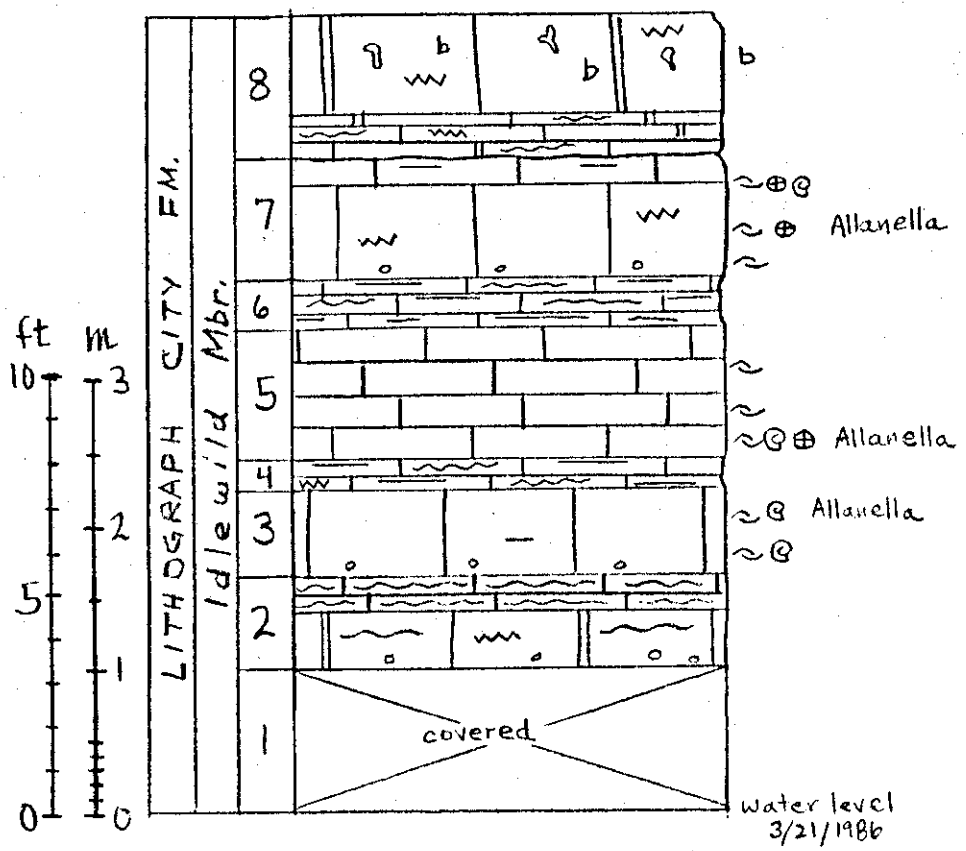
The Osage Springs Member, as displayed in the Yokum Quarry, is a prominent fossiliferous unit, with a well-developed biostrome (unit 16) at the top. Hemispherical and branching stromatoporiods are common in the biostrome. The top of the biostrome forms the lower bench on the west-southwest side of the quarry; note the hummocky upper surface developed on top of the biostrome across the bench floor area.

Overlying the Osage Springs biostrome is a prominent shale unit (units 17-18) termed the Thunder Woman Shale. This exposure is the type section of the Thunder Woman Shale . The shale lacks skeletal fossils, but burrows are common in the upper part.

The upper part of the quarry (upper bench level) exposes an atypical section of the Idlewild Member. Amphipora biostromes are prominently developed in the upper part, however the stromatoporiods within this interval are not a boundstone and may have been transported to this site. An intraclastic unit with abundant quartz sand is present in the uppermost part of the section. Quartz sand has not been noted as a major constitutent within the Idlewild

Member elsewhere. The Idlewild as exposed at Yokum Quarry may represent a possible tidal channel facies within the upper Lithograph City Formation.

NOTES



KEY

- branching stromatoporoids
- domal stromatoporoids
- indeterminate fossil debris
- burrows
- stromatactis structures
- stylolitic
- bivalves
- small tabulate corals
- fractures

STOP 2. Lubben Quarry, northwest quarry area - south of Greene, c E 1/2 NW section 25, T93N, R17W; Butler County. Additional lithologic key in Figures 4 & 6.

STOP 2 - LUBBEN QUARRY - south of Greene, owned and operated by Greene Limestone Company (section measured by B.J. Witzke, Iowa Geological Survey and J. Day, University of Iowa, 1986)

LOCATION - center E 1/2 NW Section 25, T93N, R17W, Butler County; elevation of the top of the quarry section is approximately 980′ (sea level datum)

MIDDLE or UPPER DEVONIAN
CEDAR VALLEY GROUP
LITHOGRAPH CITY FORMATION

IDLEWILD MEMBER

UNIT 8 - Limestone, very fine to sublithographic, stylolitic; lower 30 cm in 5 beds, in part laminated; top 70 cm is a massive limestone with scattered birdseye and stromatactis structures; 1.0 m.

UNIT 7 - Limestone, skeletal wackestone to packstone, massive, stylolitic; intraclasts and brachiopods near base; brachiopods, crinoid debris (including circular and star-shaped columnals), gastropods in middle part; upper part with similar fauna, becomes rubbly-bedded near top; 87 cm.

UNIT 6 - Limestone, extremely fine, thinly bedded, with shale partings, wavy argillaceous laminations and partings; 33 cm.

UNIT 5 - Limestone, very fine to extremely fine, skeletal wackestone to packstone, stylolitic, in 4 beds; lower bed packstone with brachiopods (Allanella), gastropods, crinoid debris; brachiopod wackestone beds above, becoming less skeletal at top (skeletal mudstone); 90 cm.

UNIT 4 - Limestone, very fine, thin bedded to shaley, stylolitic,, in part laminated; 22 cm.

UNIT 3 - Limestone, extremely fine to very fine, skeletal wackestone, brachiopods (Allanella), gastropods; intraclastic at base; becomes less skeletal at top; 58 cm.

UNIT 2 - Limestone, extremely fine to sublithographic, intraclastic at base; lower bed with coarse faint laminations, stylolitic; top 24 cm is thinly bedded and finely laminated; 64 cm.

UNIT 1 - Mostly covered to quarry floor; Limestone; 1.0 m.

STOP 2. LUBBEN QUARRY south of Greene

Discussion. A portion of the Idlewild Member is exposed at this quarry. The section exposed here is more typical of the Idlewild Member as recognized at its type section than that observed at Stop 1 (Yokum Quarry). Small cyclic packages of laminated, lithographic, and intraclastic limestone interbedded with fossiliferous brachiopod (Allanella common) and crinoid-bearing intervals are noted. A birdseye and "stromatactis" bed (unit 8) is developed at the top of the quarry. Pandorinellina insita has been recovered from the fossiliferous intervals, as well as a variation (?) of P. inista with well-developed platforms from unit 3.

STOP 3 - AUREOLA HILLS
Maxson Quarry - owned and operated by Greene Limestone Company (section measured by B.J. Witzke, Iowa Geological Survey and J. Day, University of Iowa, 1986)

LOCATION - NW SE SE SECTION 7, T94N, R17W; Floyd County; elevation of the top of the quarry section is approximately 1000' (sea level datum)

UPPER DEVONIAN
CEDAR VALLEY GROUP
SHELL ROCK FORMATION

MASON CITY MEMBER

UNIT 14 - Limestone, skeletal wackestone to packstone; crinoid debris, gastopods, bivalves (Paracyclas), brachiopods (Spinatrypa, Cyrtina, etc.); basal 12 cm, limestone, part finely laminated, some birdseye; 75 cm.

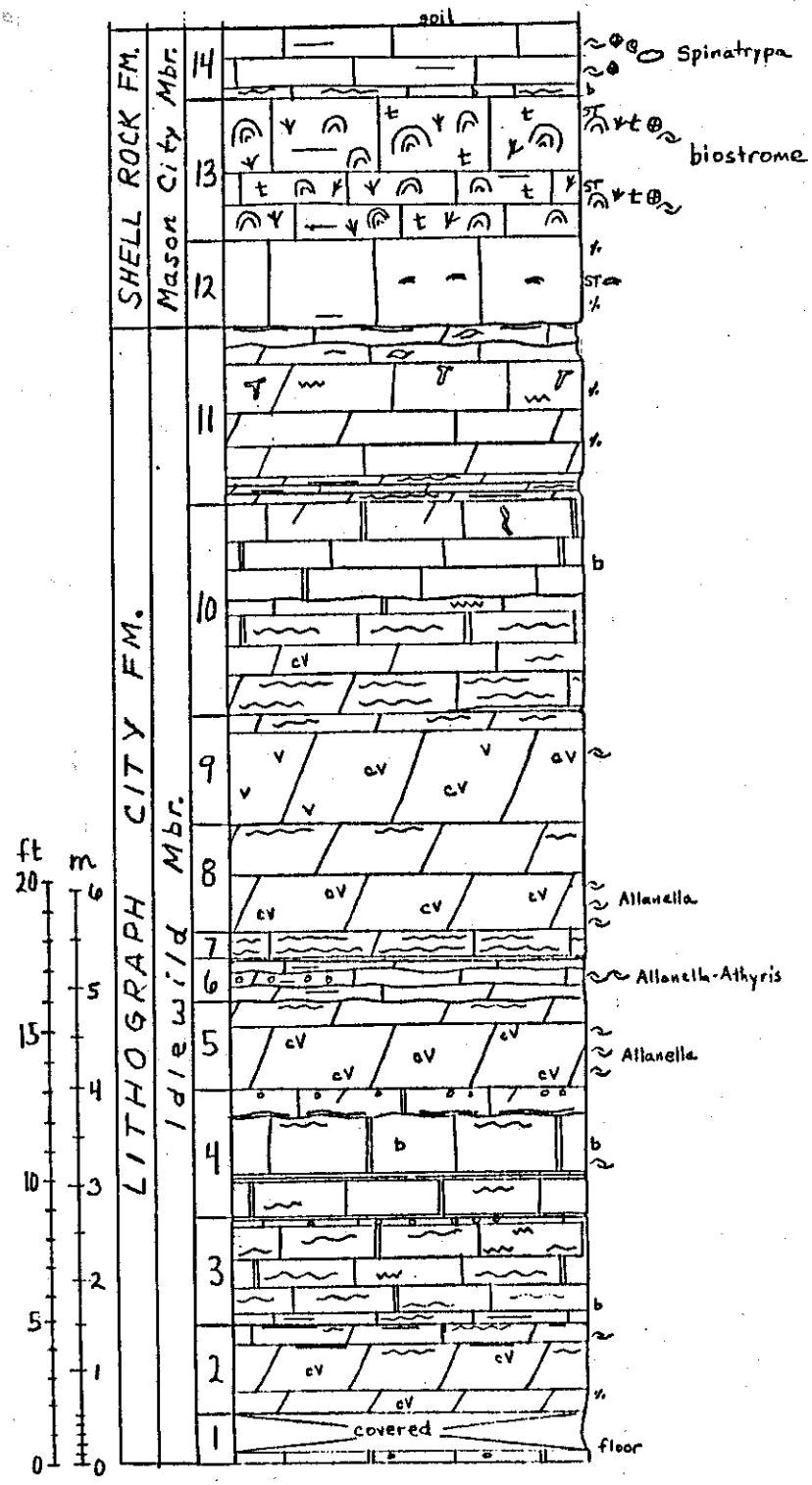
UNIT 13 - Limestone, biostrome, abundant hemispherical stromatoporoids (to 25 cm), branching stromatoporoids, thamnoporid corals, brachiopods (Cyrtina, etc.), crinoid debris; 1.45 m

UNIT 12 - Limestone, massive, fine skeletal wackestone, brachiopods present, small laminar stromatoporoids (1 mm thick) in middle part (fragmented to imbricated); 87 cm.

MIDDLE to EARLY UPPER DEVONIAN
CEDAR VALLEY GROUP
LITHOGRAPH CITY FORMATION

IDLEWILD MEMBER

UNIT 11 - Limestone, dolomitic, extremely fine; in top 93 cm, calcite-filled vugs, stylolitic, dolomitic mottling, "stromatactis," part with fine skeletal debris; uppermost 40 cm is rubbly bedded, semi-nodular, probable pre - Shell Rock weathered horizon, thin shale at



STOP 3. Maxson Quarry (Aureola Hills section), east wall - west of Marble Rock, NW SE SE section 7, T94N, R17W; Floyd County. Litholgic key in Figures 4 & 6, and Stop 2.

top; lower 91 cm, dolomite, very fine - fine, nodular appearance with dolomitic limestone surrounded by dolomite matrix, fine skeletal debris, calcite fracture fill; basal 26 cm is argillaceous dolomite, thin-bedded, laminated, recessive; 1.84 m.

UNIT 10 - Limestone, extremely fine to sublithographic, faintly to finely laminated in lower half; upper half, stylolitic, dolomitic near top, calcite filled fractures, some birdseye; lower 70 cm is replaced to north by dolomite, laminated; basal 7 cm shale to south; 2.13 m

UNIT 9 - Dolomite, extremely vuggy, calcite-filled and lined vugs, mostly massive, brachiopods in upper part; top 20 cm is separate bed, dense, non-vuggy dolomite, faintly laminated; 1.15 m.

UNIT 8 - Dolomite, fossil-moldic, abundant Allanella, calcite -filled vugs in lower half; upper half, dolomite, dense, non-moldic, part faintly laminated; 1.13 m.

UNIT 7 - Limestone, dolomitic, thin-bedded, finely laminated; 25-30 cm.

UNIT 6 - Limestone, dolomitic limestone, and calcareous dolomite; lower calcareous dolomite faintly laminated with flat-pebble intraclasts to 2 cm; middle limestone to dolomitic limestone is locally a brachiopod (Allanella, Athyris) packstone, replaced laterally by intraclast conglomerate; upper part slightly dolomitic limestone; 6 cm green-gray shale at top; 46 cm.

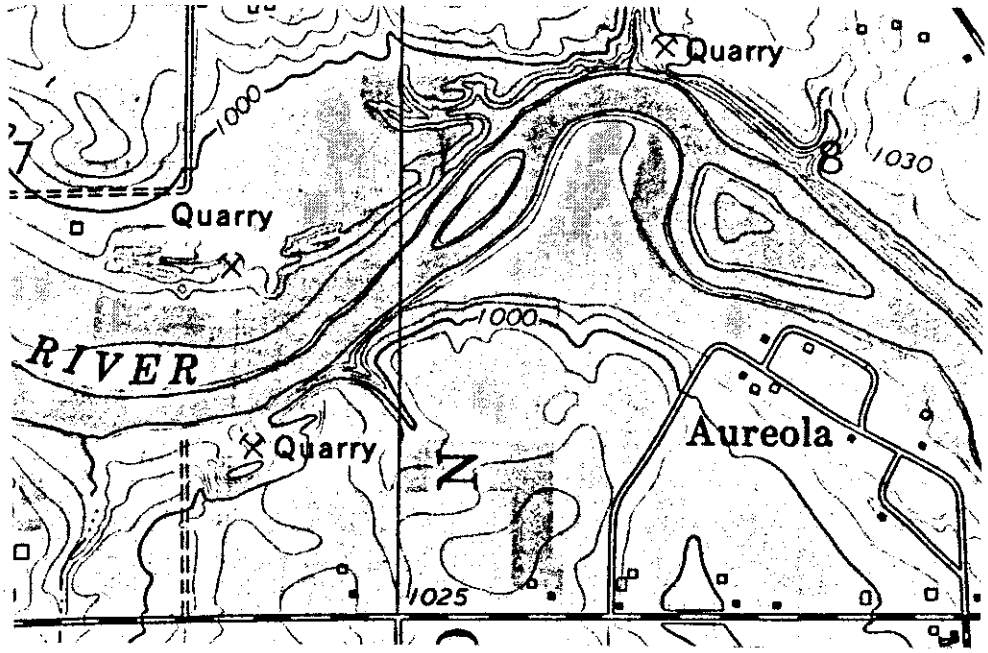
UNIT 5 - Dolomitie, fossil-moldic and vuggy, calcite-filled vugs, vugs to 8 cm, brachiopods common to abundant through most of unit, especially 35 cm above base; upper 26 cm is dense, non-moldic dolomite, faintly laminated near top; undalating upper surface; 86 cm.

UNIT 4 - Limestone, extremely fine to sublithographic, conchoidal fracture, massive beds interbedded with green-gray calcareous shale (2-9 cm); top 10 cm intraclastic in dolomitic matrix; middle bed faintly laminated near top, scattered birdseye, brachiopods near base; lower bed with some faint laminations; 1.31m.

UNIT 3 - Limestone, extremely fine to sublithographic, faintly laminated, stylolitic, argillaceous near base; top bed part intraclastic; 3-5 cm shale at top; 1.19 m.

UNIT 2 - Dolomite to dolomitic limestone at top; very fine to finely crystalline, calcite-filled and lined vugs through most of unit; skeletal debris molds near base, brachiopods in top bed; part slightly argillaceous; faintly laminated in top bed with shaley partings; 97 cm.

UNIT 1 - Mostly covered; quarry floor is dense Limestone, extremely fine to sublithographic, with scattered intraclasts; 50 cm.

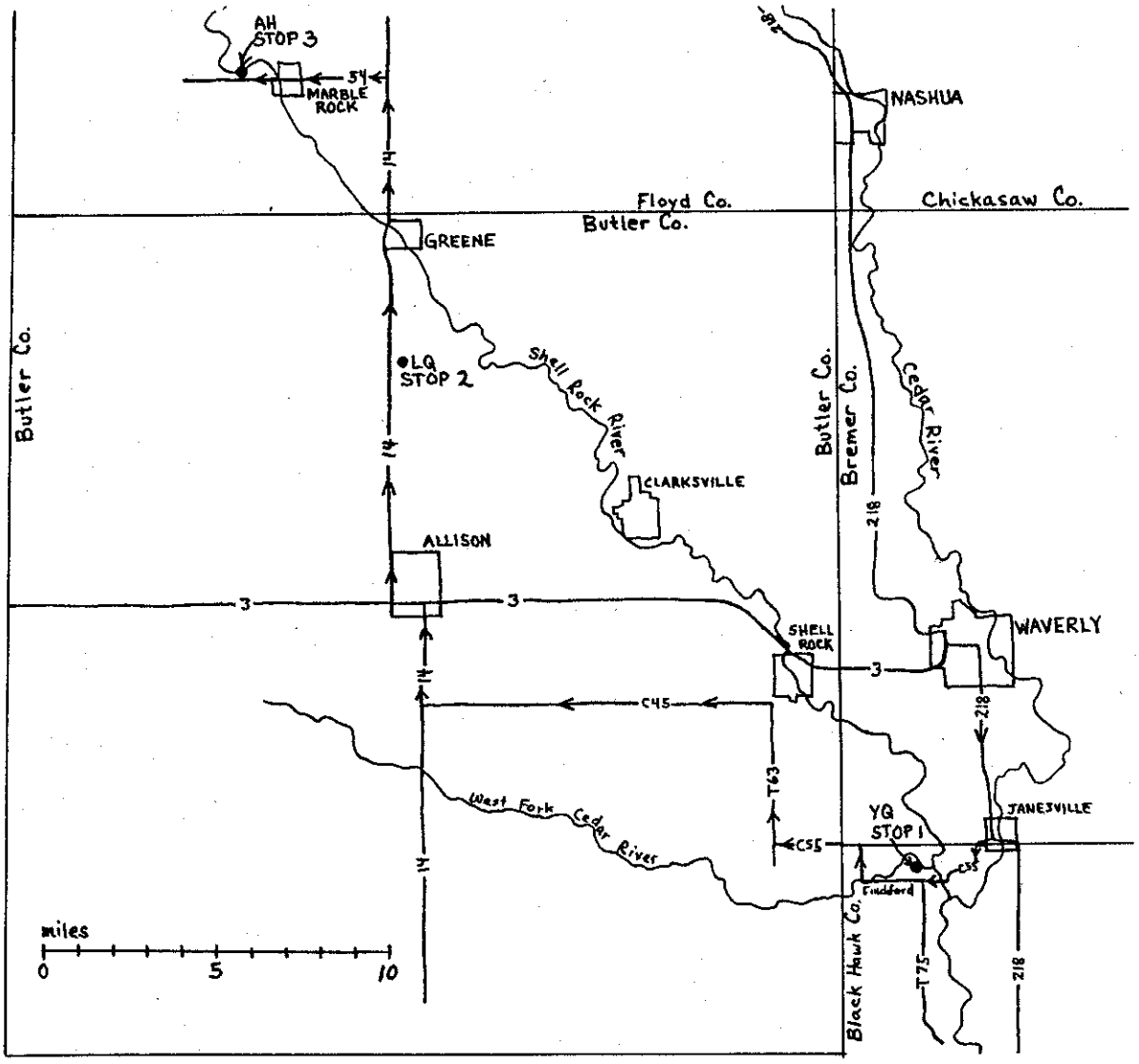


Map showing location of Maxson Quarry (south side of river) in the hills to the west of the community of Aureola (Aureola Quadrangle).

STOP 3. MAXSON QUARRY west of Aureola

Discussion. ("DANGEROUS FACE -- USE EXTREME CAUTION'" -- HARDHATS REQUIRED). The section described here is referred to as the Aureola Hills Section based upon its proximity to the community of Aureola as noted in the map above. The quarry section contains an excellent exposure of the upper contact of the Idlewild Member of the Lithograph City Formation with the overlying Mason City Member of the Shell Rock Formation. Typical lithologies of the Idlewild Member are represented: laminated, lithographic, and intraclastic carbonates are interbedded with thin fossiliferous intervals (brachiopods dominate, Allanella and Athyris noted). Eleutherokomma jasperensis is known from collections of Belanski from roadcut exposures of the upper Idlewild Member just to the south of the quarry area. E. jasperensis, however, has not yet been recovered by the authors.

Stromatactis structures are noted in the upper part of unit 11. The uppermost 40 cm of the Idlewild (uppermost unit 11) is a rubbly-bedded, semi-nodular unit (possibly a pre-Shell Rock weathered horizon ?). A prominent stromatoporiod biostrome (units 12-13) characterizes the lower 2.3 m of the overlying Shell Rock Formation (Mason City Member). The brachiopod association noted in the Mason City Member (Spinatrypa, Cyrtina, etc.) differs from that present in the underlying Idlewild Member of the Lithograph City Formation (i.e. Allanella, Athyris). Gastropods, bivalves (Paracyclas) and crinoid debris are also present.



Map showing field trip stops and route. No road log is provided.