IOWA GEOLOGICAL SURVEY
IOWA CITY, IOWA
SAMUEL J. TUTHILL, Director and State Geologist

REPORT OF INVESTIGATIONS 10

STRATIGRAPHY OF THE UPPER DEVONIAN SHELL ROCK FORMATION OF NORTH-CENTRAL IOWA

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DONALD L. KOCH

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CONTENTS

ILLUSTRATIONS

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ABSTRACT

The principal exposures of the Upper Devonian Shell Rock Formation occur along the Shell Rock River in north-central Iowa. Three members, the Mason City, Rock Grove and Nora are recognized. Except for the Upper Devonian State Quarry Limestone in northern Johnson County, the Shell Rock Formation has the smallest areal extent of any formation in Iowa and attains a maximum thickness of only 65 feet.

The Shell Rock Formation lies unconformably between the Middle Devonian Cedar Valley Limestone and the Upper Devonian Lime Creek Formation. Outliers of Cretaceous sandstones and shales lie unconformably upon the Shell Rock Formation along its eastern outcrop margin.

The formation consists of a series of argillaceous limestones, dolomites and shales, and prominent coralline and stromatoporoid biostromes. Stromatoporoid biostromes predominate in the upper part of the formation and indicate successive transgressions of the late Shell Rock sea. During the time of their formation these biostromes extended over shallow banks or shoals and covered a larger area than the lower beds. A discussion of the changes in the physical and mineralogical characteristics of each member as observed in the outcrop section and in the subsurface section outside the type area is included.

Dense limestone (micrite) beds and underlying dolomite beds in the vicinity of Mason City, Iowa, have been correlated by previous workers as facies equivalents of the lower two members of the Shell Rock Formation. However, collation of surface and subsurface data reported here demonstrates that these beds correlate with the underlying Cedar Valley Limestone and that the depositional basin of the Shell Rock Formation was more restricted than previous workers thought.

INTRODUCTION

The Shell Rock Formation of north-central Iowa has been a subject of interest to stratigraphers and paleontologists for many years. Lack of a thorough study of the surface stratigraphy of the Shell Rock Formation and the underlying Cedar Valley Limestone resulted in miscorrelations of exposures only ten miles northwest of the type locality. Furthermore, incorrect correlations were made with subsurface strata over 75 miles south of the southern limit of the formation.

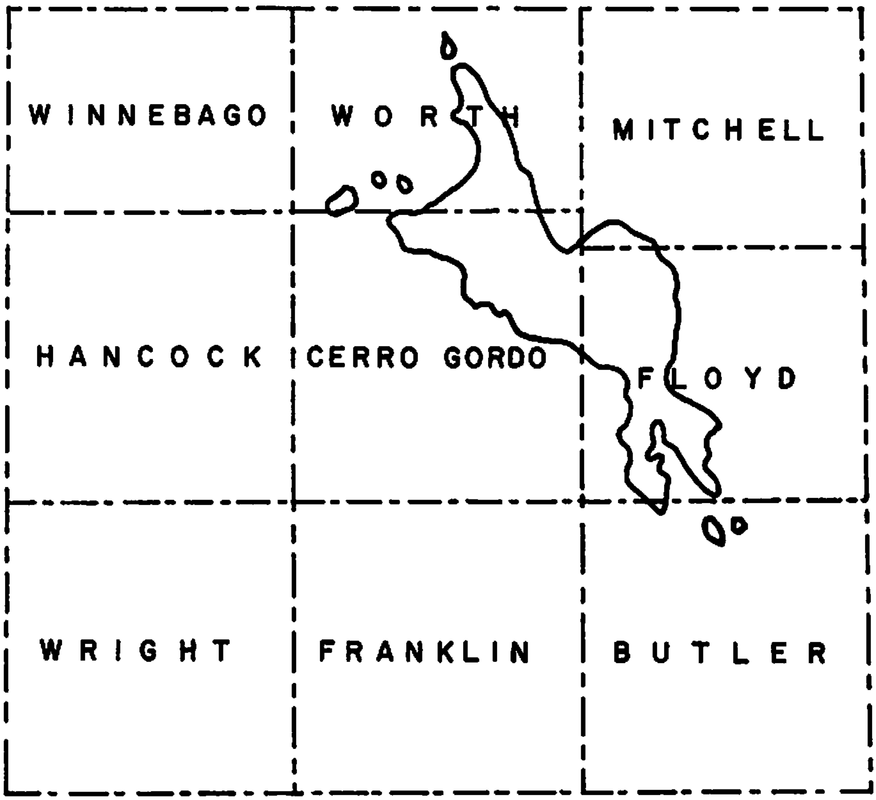
The data reported here permit a solution of the problems inherent in this portion of the stratigraphic column of Iowa. The physical stratigraphy of the outcropping Shell Rock Formation is redescribed and collated with the subsurface section.

Location and Extent

The Shell Rock Formation is limited to the eastern one-half of north-central Iowa and includes the following counties or parts thereof: northern Butler County, the western one-half of Floyd County, southwest Mitchell County, central and southwest Worth County, and the northeast one-half of Cerro Gordo County (fig. 1). The formation crops out along the Shell Rock and Winnebago (formerly Lime Creek) Rivers and their tributaries, in quarry exposures and in road cuts.

Previous Investigations

Earlier authors (Owen, 1852; Whitney, 1858; Hall and Whitfield, 1872; Calvin, 1896; and Thomas, 1913 and 1919) made passing reference to exposures along the Shell Rock River in



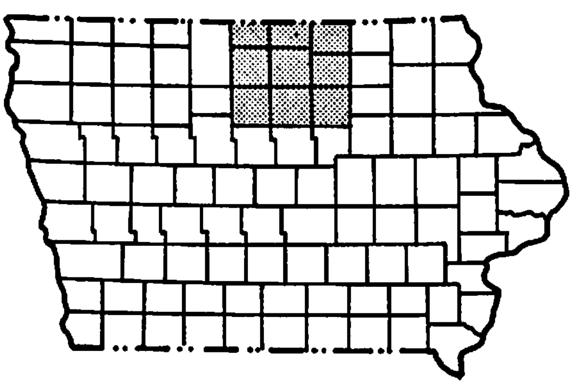


Figure 1. Outcrop area of the Shell Rock Formation.

western Floyd County, but they conducted no detailed analysis. Belanski (1927, p. 319-340) defined the "Shellrock Stage" and three "substages" on the basis of biostratigraphic studies of outcrops. Definition of rock units upon biostratigraphic zones was one accepted approach to stratigraphic studies during Belanski's time, but such an approach is contrary to modern concepts of litho-stratigraphy and rock-stratigraphic units as set forth in the Code of Stratigraphic Nomenclature (1961).

Belanski (1928b) concluded that the macrofauna of the Shell Rock Formation was indicative of an Upper Devonian assemblage. That conclusion is uncontested. He also stated that the fauna had an origin distinct from either the underlying Cedar Valley Limestone or the overlying Lime Creek Shale, and that the ancestral fauna of the Shell Rock Formation "must be sought in the Devonian of the Mackenzie basin, or more remotely, in that of the German Eifel." However, Cooper and others (1942, p. 1780) reported that a fauna similar to that of the Shell Rock Formation is widespread in western North America, occurring in the Jefferson Limestone (western Wyoming, northeastern Utah, southwestern Montana), Muddy Peak Limestone (Nevada), lower Devils Gate Limestone (Nevada), lower Minnewanka Formation (Alberta), and parts of the Sultan Limestone and Silverhorn Dolomite (Nevada). An Upper Devonian age assignment for the Shell Rock Formation is substantiated by more recent studies of its microfauna. Anderson (1964, p. 19) included a number of sections of the Shell Rock Formation in his study of Upper Devonian and Lower Mississippian conodonts of north-central Iowa. Although only a meager conodont fauna was recovered the forms identified indicate that the members of the Shell Rock Formation are assignable to the Upper Devonian *Manticoceras Zone*.

Stratigraphic Data

In this study information from outcrops was supplemented by subsurface data. Representative hand specimens were collected for examination under a binocular microscope and, from a few beds, for thin section preparation. Drill cuttings that penetrated the Shell Rock Formation and adjacent formations were examined in detail. Cores that became available during the progress of this report as a part of the Iowa State Highway Commission testing program were examined. In addition, specific core locations were selected and drilled to define the relationships of the Shell Rock Formation and the Cedar Valley Limestone where data was otherwise inadequate. In all, 105 exposures, 125 sets of drill cuttings and 14 core samples were evaluated.

Acknowledgements

This report has been prepared for the Iowa Geological Survey. The work initially was part of a Master's program at The University of Iowa and was directed by H. Garland Hershey, then Director of the Iowa Geological Survey and State Geologist.

F. H. Dorheim, Iowa Geological Survey, made helpful comments. M. C. Parker, also a member of the Survey Staff, gave advice during the preparation of maps and diagrams. S. J. Tuthill, Director of the Iowa Geological Survey and State Geologist, critically reviewed the manuscript.

Core logs were obtained from the geology section of the Iowa State Highway Commission. T. L. Welp, former chief geologist, approved a cooperative coring program between the Commission and the Iowa Geological Survey to obtain additional data.

Thanks also are due the many quarry and clay pit operators and their employees who allowed access to openings on their properties.

G. A. Cooper of the Smithsonian Institution confirmed the identification of some of the fossil specimens.

Faculty members of The University of Iowa provided suggestions during the preparation of the original thesis. The criticisms of W. M. Furnish and B. F. Glenister are gratefully acknowledged. Furnish also reviewed the final manuscript. A. C. Tester and Keene Swett offered valuable comments during the study of thin sections.

STRATIGRAPHY

Type Section Area

Inadequacy of Belanski's Definition

C. H. Belanski was not a professional geologist by training. Nevertheless, he accomplished much work on the Shell Rock

Formation, and his publications provided the most comprehensive summation on the stratigraphy and paleontology of the formation available at that time. His fossil collection, reposited at The University of Iowa, is unlikely to be surpassed.

Belanski (1927, p. 320) divided his "Shellrock Stage" into three "substages" (the Mason City, Rock Grove and Nora) and stated that the strata "lie above the beds of the Cedar Valley stage and below the blue shales of the Juniper Hill Shale, being separated from both of these formations by sharp, persistent, unconformities." The mixing of time-stratigraphic and rock-stratigraphic terms in his description of these units does not conform to the existing Code of Stratigraphic Nomenclature (1961). In addition, Belanski's definition of the "Shellrock Stage" and its three "substages" upon a biostratigraphic basis is untenable by usage as defined in the Code, and the nature of his zonation and phase(areal) descriptions is not valid. For instance, the term zone was used by him to refer to "a particular group of rocks, not necessarily retaining the same lithologic character wherever exposed but marked by a species or group of species which are especially characteristic to them." Subdivisions of his zones did not strengthen his definition of the various "stages" because the term zonule was used to refer "to a zone lithologically distinct from other zonules of the zone." A particular zone or zonule was described by Belanski as "barren" at many exposures and one of his zonules was prefixed by the lithologic term "dolomite".

Because Belanski's definitions are inadequate a redefinition of these Upper Devonian beds as the Shell Rock Formation is given in this report. The priority of Belanski's names "Mason City", "Rock Grove" and "Nora" is recognized but these names are used with the rank of member. However, the name "Shellrock" is rejected as a single word. Instead, the name Shell Rock as used by Wilmarth (1938, p. 1978) is accepted except that the word "formation" is selected rather than the lithologic designation "limestone". Thus, the Shell Rock Formation, as subsequently defined, contains three members, the Mason City, Rock Grove and Nora. An historical summary of the nomenclature used for these Upper Devonian units and the adjoining formations is given in table 1.

System	Owen 1852	Calvin 1897	Thomas 1919	Fenton and Fenton 1924	Belanski 1927 — 1928	Stainbrook 1935	IGS Present Report 1970
DEVONIAN		MIDDLE — Lime Creek Stage — Owen Substage	UPPER — Lime Creek Stage — Owen Beds	UPPER — Hackberry Stage — Owen Substage	UPPER — Hackberry Stage — Owen Substage	UPPER — Lime Creek Formation — Owen Member	UPPER — Lime Creek Formation — Owen Member
		Hack-berry Substage	Hack-berry Beds	Cerro Gordo Substage	Cerro Gordo Substage	Cerro Gordo Member	Cerro Gordo Member
				Sheffield Formation	Juniper Hill Formation	Juniper Hill Member	Juniper Hill Member
	Beds of the Shellrock Valley	Cedar Valley Stage — Mason City Substage	Division Suggested but not made	MIDDLE — Cedar Valley Stage	Shellrock Stage — Nora Substage	Shellrock Formation — Nora Member	Shell Rock Formation — Nora Member
					Rock Grove Substage	Rock Grove Member	Rock Grove Member
					Mason City Substage	Mason City Member	Mason City Member
			Cedar Valley Stage		MIDDLE — Cedar Valley Stage	Cedar Valley Limestone — Coral-ville Member	MIDDLE — Cedar Valley Limestone — Coral-ville Member

Table 1. Nomenclature of Devonian Formations in north-central Iowa.

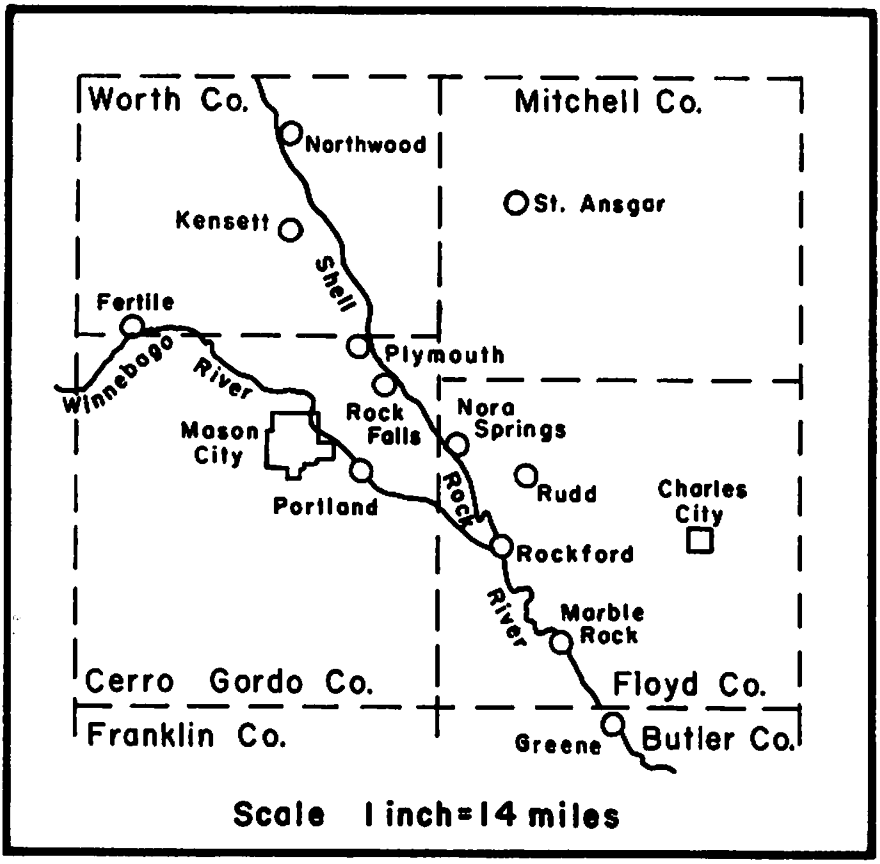


Figure 2. Geography along Shell Rock and Winnebago Rivers.

Redefinition of the Shell Rock Formation

The name Shell Rock Formation is designated for the interval of Upper Devonian beds in north-central Iowa that lies unconformably above the Cedar Valley Limestone (Middle Devonian) and beneath the Lime Creek Formation (Upper Devonian). The type area of the Shell Rock Formation is along the Shell Rock River in the vicinity of the town of Nora Springs (fig. 2). The formation is divided into three members, the Mason City, Rock Grove and Nora. A separate location is given for the type section of each member because the entire formation is not exposed at any one location.

In the type area the Shell Rock Formation consists of a series of moderately argillaceous limestones, dolomites, and dolomitic limestones and shales. Prominent fossiliferous zones include crinoidal and coralline limestones, distinct biostromes, and strata containing many brachiopods. The lower biostromes are dominated locally by a coral fauna. Those higher in the section are composed either of a mixture of corals and subspherical stromatoporoids or are dominated by massive, tabular stromatoporoids.

The Shell Rock Formation is separated from the underlying Cedar Valley Limestone by an erosional unconformity. A slightly undulatory surface is characteristic of the top of the Cedar Valley Limestone in the type area and is stratigraphically lower than in exposures to the west, north and east. Near the towns of Plymouth and Rock Falls the truncation of Cedar Valley Limestone beds is conspicuous.

Shale beds of the Lime Creek Formation lie unconformably on the Shell Rock Formation. Abraded fish teeth are abundant in a pyritic, argillaceous dolomite at the base of the Lime Creek Formation (Juniper Hill Member) near the geographic center of the occurrence of the Shell Rock Formation. At these locations the Lime Creek Formation lies on the top member (Nora Member) of the Shell Rock Formation. Farther south, the Lime Creek Formation lies unconformably on a lower bed of the Nora Member. Beyond the southern limit of the Shell Rock Formation, the Lime Creek Formation lies unconformably on the Cedar Valley Limestone.

The Shell Rock Formation crops out in an elongate belt along a northwest-southeast trending line from north-central Worth County southeasterly to northern Butler County, a distance of about 45 miles. This belt of outcrop is about 16 miles wide at its greatest width and the formation extends southwesterly only about five more miles where it is covered by younger indurated beds. Maximum thickness of the formation is 65 feet.

Mason City Member

The type section of the Mason City Member is along the east bank of the Shell Rock River in the western part of the town of Nora Springs (east line of west½, SE¼, Sec.7, T. 96 N., R. 18 W., Floyd County, Iowa). At this location beds of the Shell Rock Formation form a cliff nearly half a mile in length and about 35 feet in height. The measured section (appendix I, section 1) was described near the center of the exposure. The main face of the cliff is formed by the Mason City Member and the underlying Cedar Valley Limestone is exposed above river level. Portions

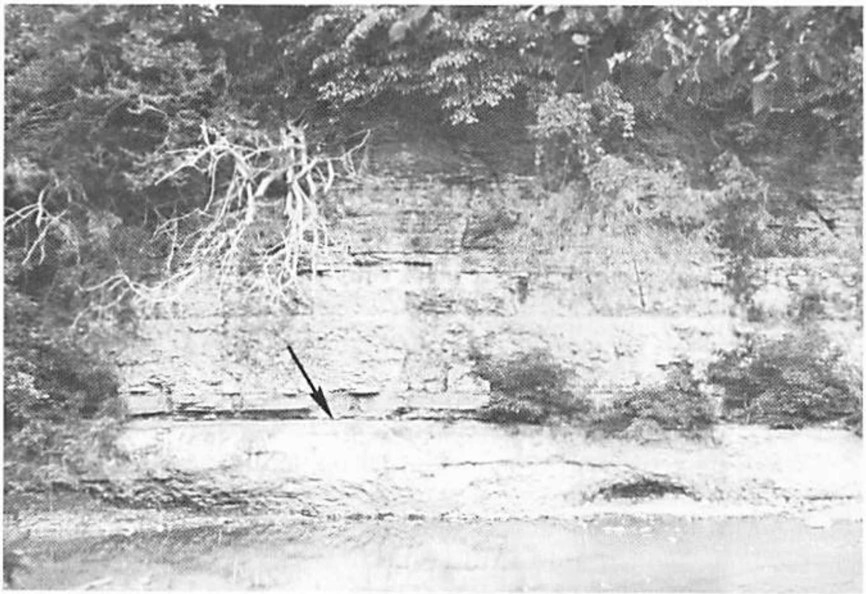


Figure 3. Contact of Mason City Member of the Shell Rock Formation with underlying Coralville Member of Cedar Valley Limestone(arrow), northern part of Nora Springs. (See appendix I, section 1).

of the Rock Grove and Nora Members are exposed on the slope above the cliff. The Mason City Member consists dominantly of thick-to massive-bedded limestones. Corals, stromatoporoids, brachiopods and crinoid fragments are common throughout the upper part and a prominent coral-stromatoporoid biostrome occurs in the lower part. The term biostrome refers to beds of predominantly autochthonous biogenic carbonate with horizontal dimensions greater than vertical dimensions. In the Shell Rock Formation these beds average five feet in thickness and generally they extend hundreds of feet laterally. The biostrome in the Mason City Member and those present in the Nora Member are conspicuous markers in the surface and subsurface sections because of their biogenic nature.

The unconformable contact of the Mason City Member with the Cedar Valley Limestone is marked by a change in lithology from dolomite (Mason City Member) to lithographic limestone (Cedar Valley Limestone). A broadly undulating surface is characteristic of the top of the Cedar Valley Limestone (fig. 3). Although the lower beds of the Mason City Member parallel this surface they are slightly thicker in the troughs and the bedding planes become nearly horizontal in the upper part of the member.

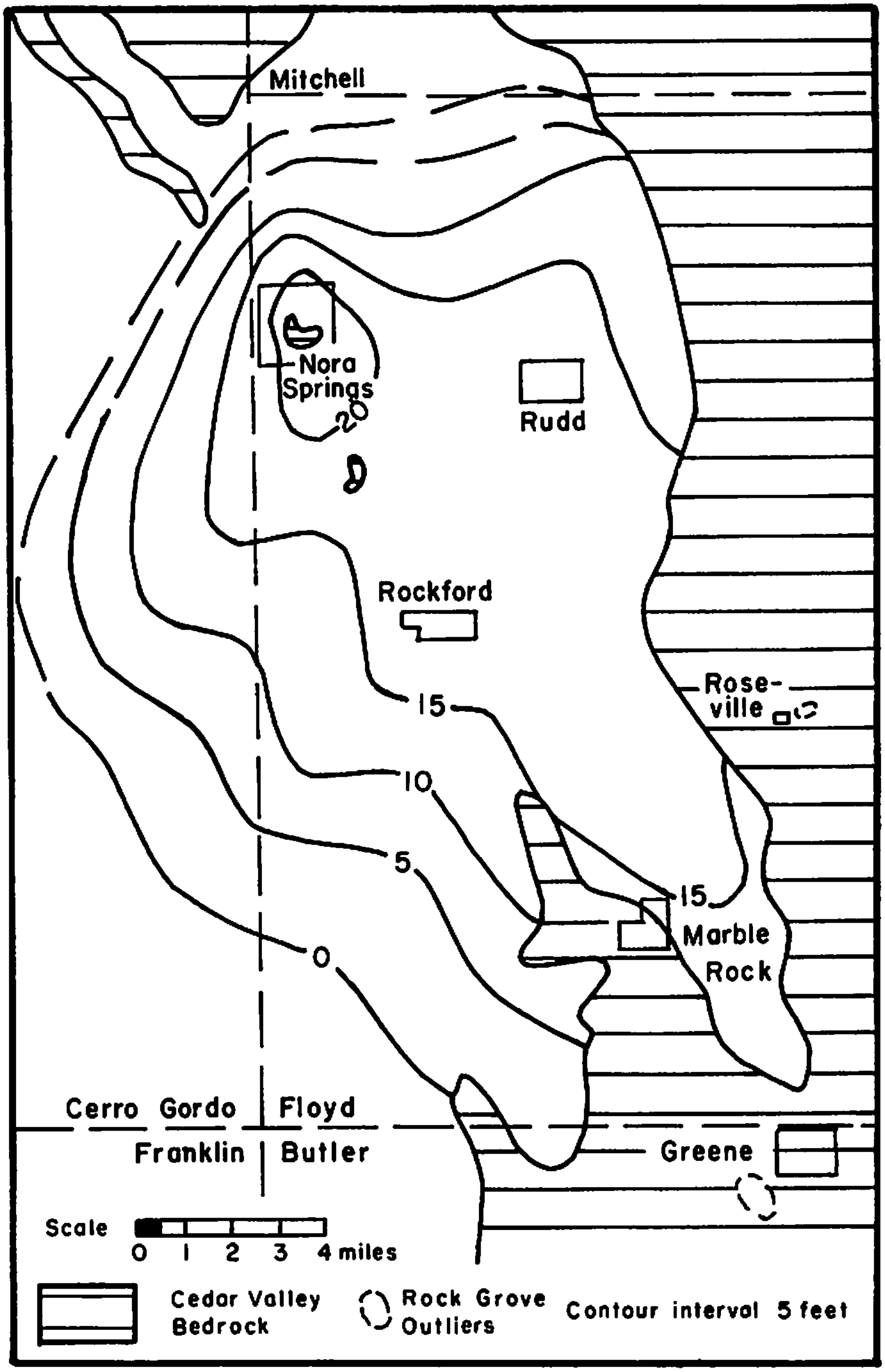


Figure 4. Isopach of Mason City Member.

The contact between the Mason City and Rock Grove Members is marked by a distinct change in bedding structure. Thin-bedded dense limestone layers separated by shale partings (Rock Grove Member) occur above the thick- to massive-bedded fossiliferous limestone of the Mason City Member. The top surface of the latter usually contains irregular shallow pits that are stained with iron oxides.

Maximum thickness of the Mason City Member at this location is 22.5 feet (fig. 4). Comparable thicknesses occur at nearby exposures, but the thickness gradually decreases south and east of Nora Springs over a distance of about 24 miles to the southeasterly limit of the formation. The decrease in thickness is much more abrupt northwest of Nora Springs. Because of overlap onto a higher surface of the Cedar Valley Limestone, beds of the Mason City Member extend only about three miles in this direction. The upper beds of the Rock Grove Member form the lowest exposed beds in this area and there is no subsurface control to define the northwesterly limit of the Mason City Member more accurately. However, exposures immediately northwest of this area show beds of the Nora Member in contact with the Cedar Valley Limestone. This same contact relationship is present at all other exposures along the course of the Shell Rock River to the northwest and at exposures along the Winnebago River from the Portland area northwesterly to the town of Fertile.

Rock Grove Member

The "type exposure" of Belanski is retained as the type section of the Rock Grove Member (east bank of Shell Rock River, NW¼, SE¼, SE¼, NW¼, Sec. 17, T. 96 N., R. 18 W., Floyd County; appendix I, section 2). An abandoned quarry was cut into the Nora Member at the top of the exposure. Beds of the Rock Grove and Mason City Members are exposed on a steep slope but they are obscured by talus and vegetation. Therefore, a reference section is designated for the Rock Grove Member (abandoned quarry, center NE¼, NE¼, Sec. 17, T. 96 N., R. 18 W., Floyd County; appendix I, section 4). Dolomitic shales, shaly limestones and calcareous dolomites are characteristic of the Rock Grove Member in the type area.

Contact relationships between the Mason City and Rock Grove Members at the reference locality are identical to those described for the type section of the Mason City Member. The well defined contact of the Rock Grove Member with the over-

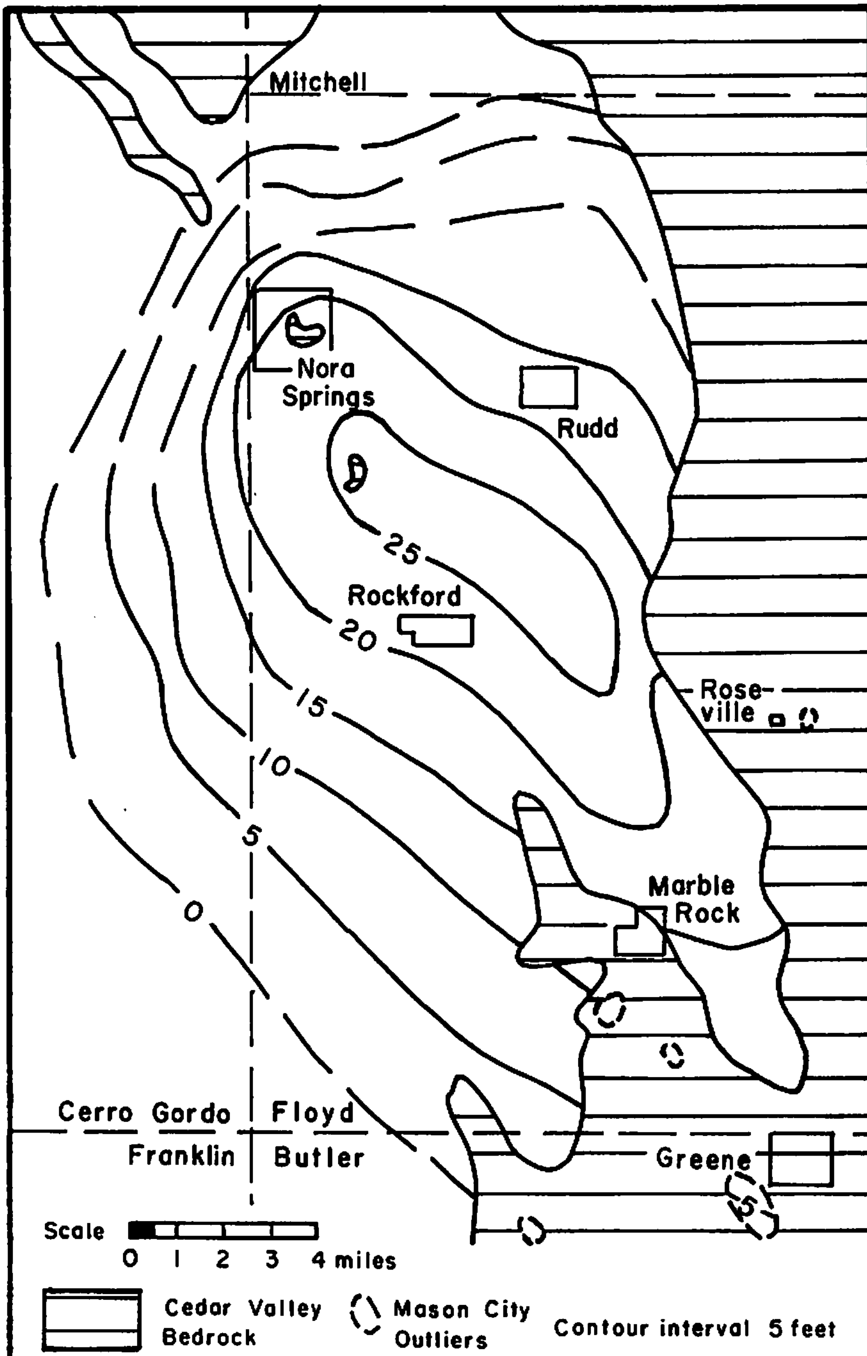


Figure 5. Isopach of Rock Grove Member.

lying Nora Member is marked by a change in lithology from massive-bedded dolomite (Rock Grove Member) to a massive limestone biostrome composed of tabular stromatoporoids (Nora Member). Cross-bedding is common in the dolomite of the Rock Grove Member.

Maximum thickness of the Rock Grove Member at this location is 22.5 feet (fig. 5). Like the Mason City Member, the reduction in thickness of the Rock Grove Member is gradual south and east of Nora Springs. Only the upper beds of this Member are exposed along the Shell Rock River immediately northwest of Nora Springs. The stratigraphic relationships described for the Mason City Member in the area three miles northwest of Nora Springs apply to the Rock Grove Member.

Nora Member

Belanski designated the "type exposure" of the "Nora substage" for an exposure near the "Junction" at the southwestern edge of Nora Springs (center NE¼, NE¼, NW¼, Sec. 18, T. 96 N., R. 18 W., Floyd County). "Junction" referred to the junction of two railroad lines at this location. The "type exposure" has since been covered with fill and only a small part of the Nora is exposed in the north-south roadcut east of the "Junction" (appendix I, section 3).

An abandoned quarry beyond the east city limits of Nora Springs is now being designated as the reference section for both the Nora and Rock Grove Members (center NE¼, NE¼, Sec. 17, T. 96 N., R. 18 W., Floyd County; appendix I, section 4). This is the most complete section of the Nora Member that is exposed in the type area. All of the underlying Rock Grove Member is exposed and the top of the Mason City Member forms the bed of a creek that flows past the northern edge of the quarry. The Nora Member contains two massive stromatoporoid biostromes that are separated by a shale interval. Throughout the report these biostromes are referred to as the lower and the upper stromatoporoid biostromes.

The contact of the Nora Member with the Rock Grove Member is marked by a change from massive-bedded dolomite (Rock Grove Member) to a limestone biostrome (Nora Member). This contact is slightly undulatory; the undulations are not evidence of an unconformity as interpreted by Belanski. Rather, the colonies of tabular stromatoporoids began their growth in shallow

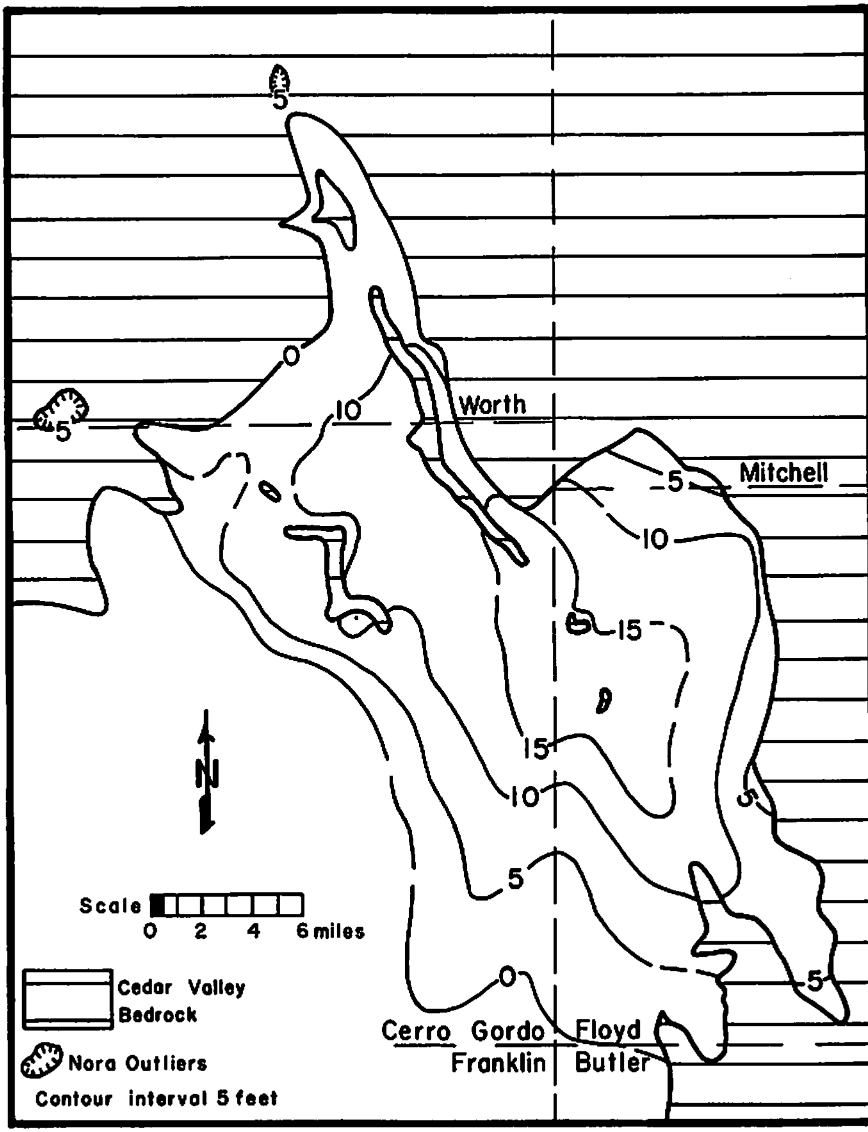


Figure 6. Isopach of Nora Member.

depressions on the surface of the Rock Grove Member and expanded upward and outward from these centers. This feature is present to some degree in all exposures of the Nora-Rock Grove contact.

At the reference locality the top of the Nora Member is concealed by a thin soil interval. Because the upper stromatoporoid biostrome has a maximum measured thickness of 6.5 feet in the type area, probably less than a foot of this bed has been removed by Pleistocene erosion. Exposures of the contact of the Nora Member with the overlying Lime Creek Formation (Juniper Hill Shale member) are referred to later in this report. None of these outcrops are adequate to be designated as reference sections because only a portion of the upper stromatoporoid biostrome is exposed beneath the Juniper Hill Shale.

The Nora Member is the most widespread member of the Shell Rock Formation. Its maximum thickness in the type area is 19 feet (fig. 6). Three miles north of Nora Springs and beyond to the northern limits of the Shell Rock Formation the Nora Member is the only unit of the formation present. This same relationship exists near Portland and Mason City. Only the lower biostrome of the Nora Member is present near the northern and western boundaries.

Stratigraphy Outside the Type Area

Orientation Statement

The reader is guided on an areal survey by which the stratigraphic relationships of the Shell Rock Formation and the Cedar Valley Limestone are demonstrated outside the type area. Variations in thickness, facies changes, and changes in the biostromes that reflect different ecologic conditions are the factors emphasized.

The areal survey is presented in three traverses that originate in the type area and radiate to the limits of the Shell Rock Formation. In the first traverse, analysis is made of exposures east and south of the type area of the Shell Rock Formation. Facies changes in the Shell Rock Formation and in the Cedar Valley Limestone are minor throughout this area and contact relationships between the two formations are clear. A decrease in thickness of the Shell Rock Formation because of overlap upon an increasingly higher surface of the Cedar Valley Limestone is the primary change to be noted in this area.

On the second traverse exposures along the Shell Rock River northwest of the type area of the Shell Rock Formation are discussed. Initially, minor facies changes are noted in the Nora Member. Farther northwest a change in the morphologic form of the stromatoporoids in the lower biostrome of the Nora Member is noted. The principal objective of this traverse is to demonstrate the error in correlations made by earlier stratigraphers in this area. The data show that beds previously correlated with the Mason City and Rock Grove Members of the Shell Rock Formation are stratigraphically higher beds of the Cedar Valley Limestone than are present in the type area of the Shell Rock Formation.

Because the Lime Creek Formation is the bedrock west of Nora Springs it is necessary to cross the drainage divide between the Shell Rock and Winnebago Rivers to follow the third traverse. This traverse resumes in the vicinity of Portland where exposures of the Shell Rock Formation and adjoining units are followed northwesterly along the Winnebago River. The many quarries, natural exposures, drill cuttings and cores in the vicinity of Mason City provide the data to complete the areal survey of the Shell Rock Formation. The errors in previous correlation of the type noted northwest of Nora Springs also apply to this area. In addition, another facies change in the Nora Member is described.

First Traverse — Stratigraphy East and South of Nora Springs

East-southeast of the type area, the Shell Rock Formation is thinner because of overlap upon the Cedar Valley Limestone (fig. 7). A decrease in thickness is evident in the Mason City and Rock Grove Members at the town of Rudd five miles east of Nora Springs. This decrease is evidenced by thinner beds in both members and by the absence of the basal dolomite bed of the Mason City Member. A maximum thickness of 15 feet for the Rock Grove Member (compared with 22.5 feet at the type section) is obtained in a composite section of two exposures in the western part of Rudd (appendix I, section 5). Thickness of the Mason City Member is determined from the subsurface section. Deposits of Pleistocene age lie on the eroded surface of the Rock Grove Member at the site of the Rudd town well (appendix II, W-9845). There is no basal dolomite bed of the Mason City Member in the drill cuttings and there is only a 14-foot section of this member here compared with 22.5 feet at the type section. The absence of the basal dolomite bed supports the interpretation that beds of the Shell Rock Formation overlap upon the Cedar Valley Limestone with a resultant loss of the lower beds east of the type area. The eastern boundary

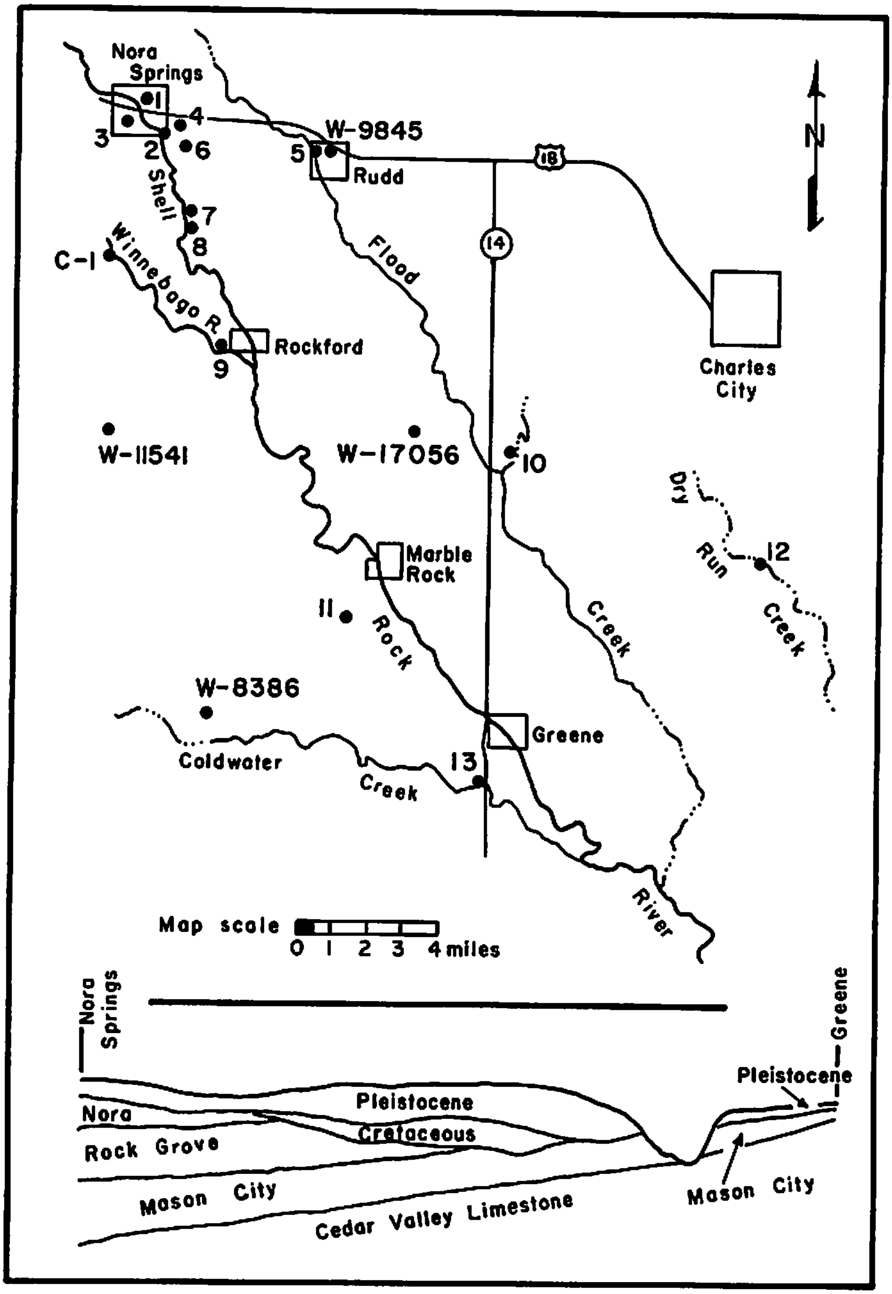


Figure 7. Route of traverse 1; numbers 1-13 refer to section descriptions in appendix I; W-11541, W-9845, etc. refer to well log descriptions in appendix II; C-1 refers to core 1, appendix III.

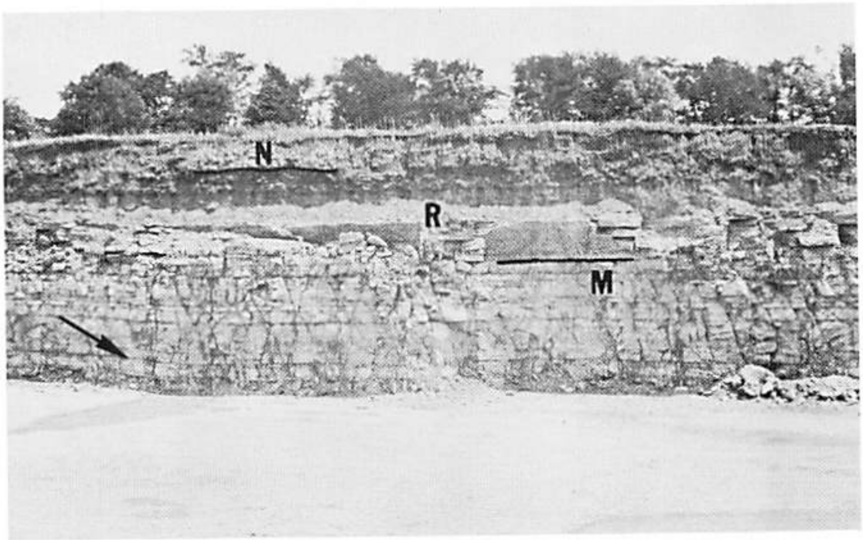


Figure 8. Nora(N), Rock Grove(R), and Mason City(M) Members in the Williams quarry; arrow marks position of discontinuity surface shown in figure 9.

of the Shell Rock Formation in this area is obscured by deposits of Pleistocene age. No drill cuttings are available and the nearest exposures are about nine miles farther east where the Cedar Valley Limestone is the bedrock.

Cretaceous sediments presumably were deposited throughout this part of Iowa, but erosion has removed all but a few remnants. An outlier of Cretaceous sandstone is exposed one mile southeast of Nora Springs (appendix I, section 6). Although the base of the sandstone is not exposed it probably lies on the Nora Member at this location because the lower stromatoporoid biostrome of that member is exposed at a slightly lower elevation just half a mile farther south. Exposures of these Cretaceous deposits validate correlations at the few locations where drill cuttings show thin intervals of Cretaceous sandstones and red shales lying unconformably upon the Shell Rock Formation.

Significant exposures of the Shell Rock Formation south of Nora Springs are limited to outcrops and quarries along the courses of the Shell Rock and Winnebago Rivers. An excellent section is exposed in the Williams quarry approximately three miles southeast of Nora Springs (fig. 8). The lower stromatoporoid biostrome of the Nora Member, all of the Rock Grove

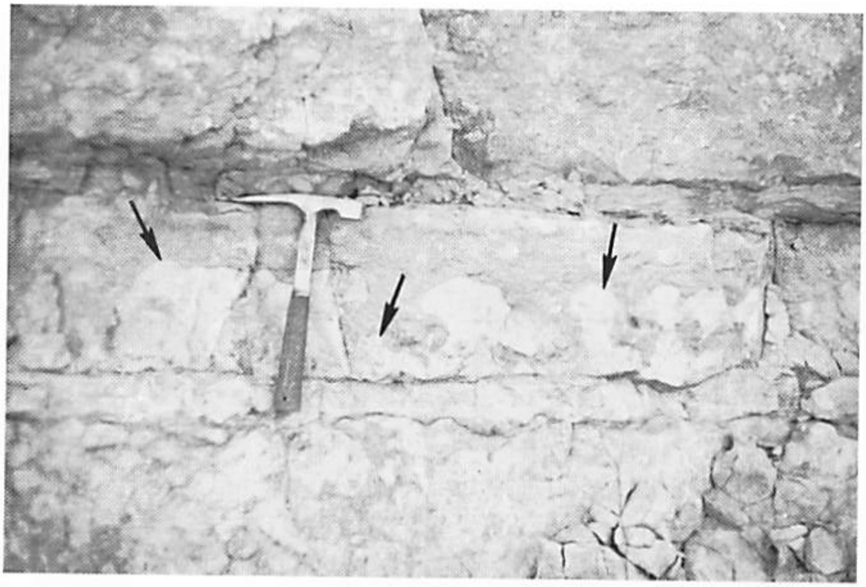


Figure 9. Discontinuity surface(arrows) in Williams quarry. (See appendix I, section 7).

Member (16.8 feet) and most of the Mason City Member are exposed in the quarry (appendix I, section 7). Immediately southwest of the quarry, along the east bank of the Shell Rock River, all of the Mason City Member (27 feet) and the upper beds of the Cedar Valley Limestone are exposed (appendix I, section 8).

Koch and Strimple (1968) have discussed the unique preservation of a biocoenose in the Mason City Member at the Williams quarry. The fauna of the biocoenose consists of edrioasteroids, cystoids, corals and worm tubes. These fossils are attached to a discontinuity surface formed on a dense limestone bed (fig. 9). The knobby limestone surface contains many borings that are filled with material from the overlying bed. These borings generally are 5-10mm in length and 1-2mm in diameter. Belanski (p. 337) reported edrioasteroids from the equivalent stratigraphic position at the exposure immediately south of the quarry, but there the discontinuity surface is at the top of a prominent biostrome of subspherical stromatoporoids. The presence of edrioasteroids attached to stromatoporoids at the top of the biostrome was interpreted correctly by Belanski to represent development of a new fauna after the biostrome had undergone a period of erosion. Only a few subspherical stromatoporoids are present below the discontinuity surface in the Williams quarry.

This lateral variation demonstrates the marked change in the composition of one bed over a relatively short distance. This change probably was a result of variation in the depth of water or the nature of the bottom configuration, or a combination of both during growth of the biostrome.

Two small quarries recently have been cut into the Nora Member on the western bank of the Winnebago River two and one-half miles southwest of the site discussed above. Although the contact is not exposed here the overlying Juniper Hill Shale can be observed in road cuts south of the quarries. The following thicknesses have been measured from a core at this location: Nora Member, 18.5 feet; Rock Grove Member, 17.1 feet; Mason City Member, 20.2 feet (appendix III, core 1). Thus, the thickness of the Shell Rock Formation is about seven feet less here than the thickness of the formation in the type area. The stromatoporoid biostrome of bed 11 in the above core is, by stratigraphic position, equivalent to the biostrome of bed 6 in the exposure south of the Williams quarry. This apparently is the most southerly occurrence of the biostrome as it is not encountered again in the surface or subsurface south of this location. The basal dolomite bed of the Mason City Member is absent here.

A minor lithologic change is noted in the middle of the Nora Member in the core discussed above and at an exposure four miles southeast (appendix I, section 9). At these two locations a thin limestone unit is present within the shale interval that separates the upper and lower stromatoporoid biostromes. This limestone is not present in the type area.

Belanski (p. 169) stated that "the contact between the two formations [Juniper Hill Shale and Shell Rock Formation] is sharply unconformable, made clearer by the sharp lithologic break. There is no evidence that the unconformity has resulted from the removal of any great thickness of Shellrock strata, even though evidence of an erosional contact is clear." Obviously this is an ambiguous statement. For the purpose of clarification it is noted that wherever this contact is exposed, the Juniper Hill Shale lies above the upper stromatoporoid biostrome of the Nora Member. There is other evidence in addition to the "sharp lithologic break" to define the unconformity between the Shell Rock Formation and the Juniper Hill Shale. Subsurface studies demonstrate that, at locations east and west of Rockford, the Juniper Hill Shale immediately overlies the lower stromatoporoid biostrome of the Nora Member (appendix II, W-11541). It is not known whether this condition is due to non-deposition of the upper biostrome of the Nora Member or pre-Juniper Hill Shale erosion (pl. I).

Up to one foot of light-colored limestone is exposed above water level along the east bank of the Shell Rock River south of the dam in Rockford. The limestone is lithographic (uniform micrite) and the surface shows numerous borings that are slightly over 1mm in diameter and average about 10mm in length. A maximum of 0.2 foot of dark yellowish-brown, very fine sand to coarse silt-sized dolomite is present above the limestone on the highest part of the exposure. This dolomite fills the borings and other irregular voids in the limestone. Polished hand specimens and thin section studies of the limestone/dolomite contact reveal fossil organisms on the limestone surface that appear to be a species of *Aulopora*. The lack of a more completely exposed section makes correlation of this exposure somewhat tenuous. Possibly, it is the contact of the Shell Rock Formation with the Cedar Valley Limestone. However, the limestone is more nearly like the lithographic limestone of the Mason City Member in bed 2 at the Williams quarry (appendix I, section 7). If a correlation with the Shell Rock Formation is correct, the dolomite overlying and filling the borings in the limestone is equivalent to the dolomite that occurs above the discontinuity surface in the Williams quarry. This outcrop would therefore be the time-stratigraphic equivalent of that same discontinuity surface. This second exposure differs from the Williams quarry exposure in that the discontinuity surface occurs here at a slightly lower stratigraphic position and the echinoderm fauna that is attached to the surface in the Williams quarry is absent.

Exposures south and east of the Rockford area offer only partial sections of the members of the Shell Rock Formation. A significant section was obtained from drill cuttings five miles southeast of Rockford. At this location Cretaceous sandstones and shales lie unconformably above the Mason City Member. This location also marks the approximate southeasterly limit of the basal dolomite bed of the Mason City Member (appendix II, W-17056).

A section of the basal Rock Grove Member and five feet of the Mason City Member lying on the Cedar Valley Limestone is exposed in a roadcut one-half mile east of the town of Roseville (appendix I, section 10). Cuttings from wells in the area generally show a Pleistocene-eroded surface of the Cedar Valley Limestone, but at a few locations a veneer of the Mason City Member is preserved. The basal dolomite of the Mason City Member is absent at the roadcut exposure and from the well cuttings. Absence of the basal dolomite supports the interpretation that Shell Rock deposition encroached upon a higher Cedar Valley surface through time.

Incomplete sections of the Shell Rock Formation are exposed south of Marble Rock where only the lower part of the Mason City Member is preserved above the Cedar Valley Limestone. Such an exposure is located in an abandoned quarry 1½ miles southwest of Marble Rock. At this location the basal bed of the Mason City Member is fossiliferous, calcareous shale (appendix I, section 11).

Belanski (p. 357) reported a remnant cap of the lower stromatoporoid biostrome of the Nora Member half a mile east of the above described quarry section. The biostrome was not observed here during this study, but its presence beneath the soil would mark the most southerly occurrence of the Nora Member. South of this location the Lime Creek Formation forms the bedrock. Three and one-half miles southeast of the last-described quarry section drill cuttings show the Juniper Hill Shale lying on the stromatoporoid-bearing Cedar Valley Limestone (appendix II, W-8386; plate I). The southwestern boundary of the Shell Rock Formation therefore is at a point intermediate to these two locations. In support of this statement it is necessary to comment on the identification of stromatoporoids in drill cuttings. When drill chips show the presence of stromatoporoids, one usually can demonstrate whether they are (1) subspherical (globular) colonies or (2) massive, tabular colonies. The subspherical forms are readily identifiable when their diameters are eight inches or less. If they are larger the low curvature of the laminae and the small size of the drill chips prevent separation of the two forms. The subspherical stromatoporoids in the Mason City Member and in the Cedar Valley Limestone rarely are greater than eight inches in diameter and they average four inches. In addition, the distinctly tabular stromatoporoids never have been observed in exposures of the Cedar Valley Limestone. The subspherical forms are, however, found in the Cedar Valley Limestone, either forming a distinct biostrome or scattered in a limestone matrix. For these reasons, and because of the characteristics of the containing limestone, the interval of stromatoporoid-bearing limestone beginning at 120 feet in the above-mentioned well is correlated with the Cedar Valley Limestone. Cuttings from other nearby wells also show lithographic limestone beds of the Cedar Valley (with traces of subspherical stromatoporoids) immediately below the Juniper Hill Shale.

An outlier seven miles south of Charles City is the easternmost exposure of the Shell Rock Formation. At this location a maximum of 5½ feet of the Mason City Member is present on top of the Cedar Valley Limestone (appendix I, section 12). The shale bed at the base of the Mason City Member is the same lithology recorded in the vicinity of Marble Rock.

The area south of Greene is the final area to be discussed on this first traverse, and the trend previously noted between this region and Nora Springs is maintained. Maximum thickness of the Mason City Member at an exposure 1½ miles south of Greene is 4½ feet (appendix I, section 13). Pleistocene erosion has removed all but three feet of the Rock Grove Member. Subspherical stromatoporoids, *Amphipora* and calcisphere structures are characteristic of the Cedar Valley Limestone at this location. The typical calcisphere is a spherical chamber ⅛mm in diameter with a mosaic of calcite within the chamber and a thin wall of anhedral calcite. This exposure, together with others within a distance of half a mile where less than five feet of the Mason City Member are present, is the most southerly occurrence of the Shell Rock Formation. The bedrock farther south is the Cedar Valley Limestone.

Second Traverse — Stratigraphy Northwest of Nora Springs

The area included on this traverse is shown in figure 10. Changes in the Shell Rock Formation northwest of Nora Springs occur over a shorter distance than those observed to the southeast. Lithologic changes, faunal variations, and an abrupt decrease in thickness of the formation are conspicuous. As previously noted, the Shell Rock Formation thins progressively southeast of the type area because of a decrease in thickness of the

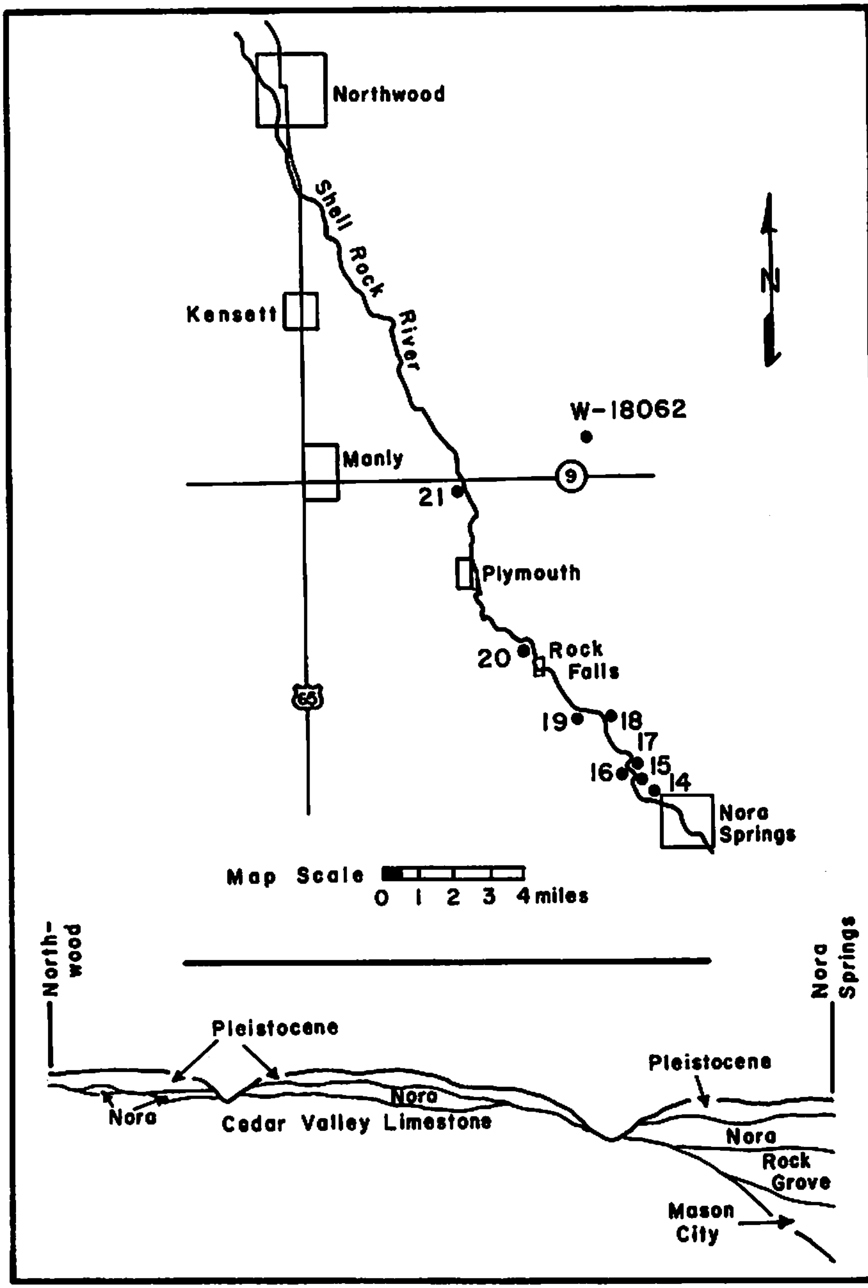


Figure 10. Route of traverse 2; numbers 14-21 refer to section descriptions in appendix I; W-18062 refers to the well log description in appendix II.

Figure 11. Subspherical stromatoporoids and *Amphipora* in lower biostrome of the Nora Member; note hand level for scale.

upper beds and the absence of lower beds as they overlap upon the Cedar Valley Limestone. Still, a portion of at least two of the three members can be recognized in exposures and in the subsurface section. In sharp contrast to the southeast area, the Nora Member is the only interval of Shell Rock strata present above the Cedar Valley Limestone north of a point about three miles northwest of Nora Springs. This relationship is observed at all locations farther northwest and to the west near Mason City. Belanski (p. 367) correlated the carbonate beds which underlie the Nora Member in this area with the Rock Grove and Mason City Members of the Shell Rock Formation. However, it is demonstrated here that these carbonate beds are correlative with the Coralville Limestone member of the Cedar Valley Limestone.

The composition of the upper stromatoporoid biostrome of the Nora Member is constant wherever this unit occurs. This massive biostrome, composed almost wholly of colonies of tabular stromatoporoids, is exposed northward to the town of Plymouth in northeastern Cerro Gordo County. Farther north, Pleistocene and Recent erosion have cut either into a lower bed of the Nora Member or into the beds of the Cedar Valley Limestone. Shaly beds occur locally in the middle argillaceous unit

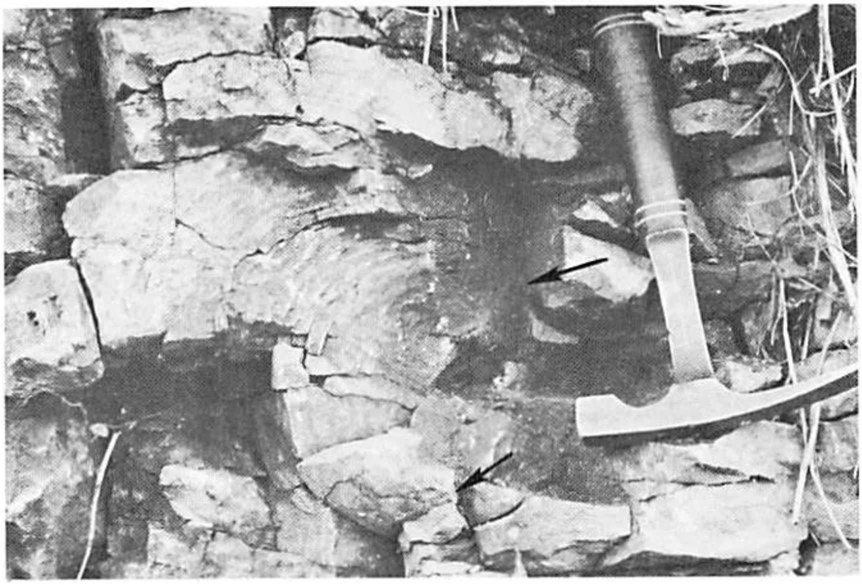


Figure 12. Large subspherical stromatoporoid; right portion was broken off and carbonate sediment subsequently filled the void; arrows mark broken edge.

of the Nora Member, but argillaceous dolomite is the dominant lithology. A change is noted in the lower stromatoporoid biostrome of the Nora Member to the northwest. Colonies of the tabular stromatoporoids, so conspicuous in the type area gradually give way to *Amphipora,* subspherical stromatoporoids, and a few tabulate and rugose corals. Still farther northwest, this interval is strongly dolomitized and fewer stromatoporoids are present.

The first change within the Nora Member is evidenced in an exposure along the eastern bank of the Shell Rock River near the Floyd-Cerro Gordo County line (appendix I, section 14). A thin bed of argillaceous dolomite is present within the shale unit that separates the upper and lower stromatoporoid biostromes. This carbonate bed is not present in the type area, but a similar occurrence of a carbonate bed in this stratigraphic position was noted in the Rockford area (appendix I, section 9). A few *Amphipora* occur throughout the lower tabular stromatoporoid biostrome, but this slender, stalked stromatoporoid is the dominant form near the top of the biostrome. Less than a foot of the Rock Grove Member is exposed at this location.

Changes within the Nora Member are exemplified further in an exposure approximately three-fourths of a mile northwest of the last-described section. At this exposure (appendix I, section 15) the middle argillaceous unit is dominantly a carbonate interval. The occurrence of subspherical stromatoporoids for the first time with the tabular stromatoporoids in the lower biostrome is striking. Less than two feet of the Rock Grove Member are exposed above river level at this location.

Continuing northwesterly, the matrix of the lower stromatoporoid biostrome is more dolomitic (appendix I, section 16). Colonies of subspherical stromatoporoids over one foot in diameter occur here, but the majority are much smaller. These subspherical forms almost completely have replaced the massive, tabular forms which are present farther south. *Amphipora* comprises a high percentage of the fauna throughout the biostrome. Most of the stromatoporoids were subjected to some degree of abrasion and fragmentation (figs. 11, 12). Weathering of dolomite in the underlying Rock Grove Member has effected a clear outline of cross-laminations. Only 6.9 feet of the Rock Grove Member are exposed here. This is the most northwesterly exposure of the Rock Grove Member.

A more complete section of the Nora Member is exposed in a small ravine about one-fourth of a mile northeast of the last-mentioned section (appendix I, section 17). A remnant of the Juniper Hill Shale is present above the Nora Member near the head of the ravine, but at all points north of this location the Juniper Hill Shale has been removed by Pleistocene erosion. Again, the more dolomitic character of the middle argillaceous unit of the Nora is evident in this exposure.

The area approximately three miles northwest of Nora Springs is the locus for determining the relationships of Shell Rock-Cedar Valley strata and for identifying the Shell Rock-Cedar Valley contact at all locations farther north and west. To demonstrate the stratigraphic relationships, it is necessary to examine a discrepancy in correlations made by Belanski. Belanski (p. 367-369) correlated the lithographic limestone beds which occur in the vicinity of Rock Falls as a facies equivalent of the lower stromatoporoid biostrome of the Nora Member. These lithographic units are the same beds that, north of Rock Falls and throughout the region of Mason City, Belanski correlated as a facies equivalent of the Rock Grove Member. The lithology of

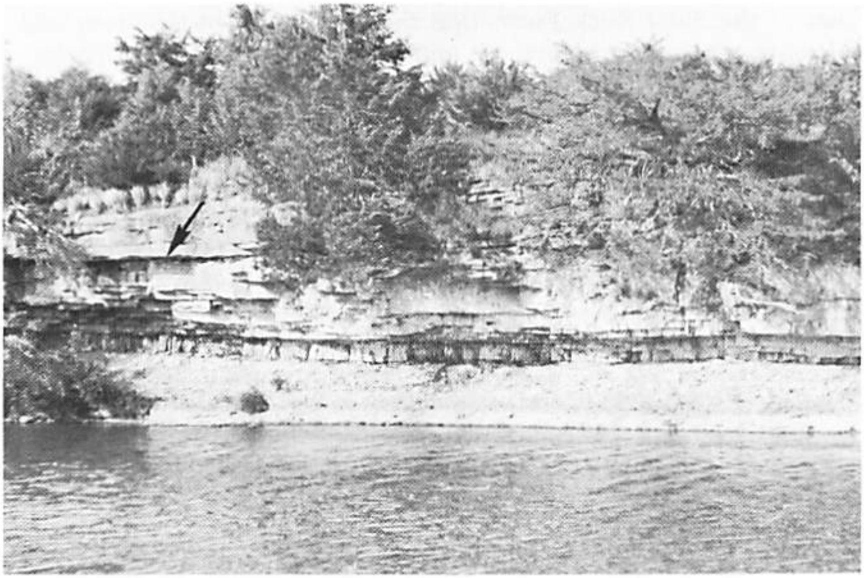


Figure 13. Contact of Nora Member with underlying Cedar Valley Limestone along Keidle's Bluff (arrow); the successively undercut dolomite beds below the Nora Member were correlated with the Rock Grove Member by Belanski, and the basal unit sloping outward toward the river was correlated with the Mason City Member.

these beds is more comparable to beds that are unquestioned correlatives of the Coralville Member of the Cedar Valley Limestone in Floyd and Butler Counties. The relief on the upper surface of this limestone, which is greatest north of Rock Falls, is evidence of an unconformity at the top of the Cedar Valley Limestone, not an unconformity within the Shell Rock Formation as proposed by Belanski. It follows then that the dolomite beds beneath the lithographic limestone unit are also a part of the Cedar Valley Limestone and are not equivalent to the Mason City Member of the Shell Rock Formation as proposed by Belanski. In summary, equivalent beds that were correlated with the lower part of the Nora Member at one location and with the Rock Grove Member at another location actually are correlative with the Cedar Valley Limestone.

The next exposure to be examined on this traverse is along a low bluff (Keidle's Bluff) located 3½ miles northwest of Nora Springs (fig. 13; appendix I, section 18). At this location, and at less accessible exposures between here and the last-described section, the unconformable contact of the Nora Member with the Cedar Valley Limestone is exposed. The Nora is the only member of the Shell Rock Formation that is present in this area and throughout the more northern and western area of the formation. The middle argillaceous unit and the lower stromatoporoid biostrome of the Nora Member have been altered by dolomitization to a greater degree in these northern exposures. In addition, there is more carbonate matrix in the lower biostrome compared with exposures to the south. The upper tabular stromatoporoid biostrome is not exposed along Keidle's Bluff, although it may be present higher on the sod-covered slope. The Cedar Valley Limestone is composed of thick- to massive-bedded dolomite in the upper part (Rock Grove Member according to Belanski), and a massive calcitic dolomite in the lower part (Mason City Member according to Belanski). Dolomitized subspherical stromatoporoids that average about two inches in diameter are concentrated on a bedding plane within the upper unit of the Cedar Valley.

Lithologic changes in both the Shell Rock Formation and the Cedar Valley Limestone are noted at an exposure on the south bank of the Shell Rock River half a mile west of the northern end of Keidle's Bluff. Here, at Baker's Bluff, the upper tabular stromatoporoid biostrome of the Nora Member is exposed above the break-in-slope and a basal dolomite bed is present at the top of the bluff (appendix I, section 19). The lower biostrome of of the Nora Member is missing. Bed 2 at Keidle's Bluff is composed of dolomite but the equivalent bed at Baker's Bluff is composed of sublithographic limestone. Subspherical stromatoporoids from one to three inches in diameter, and *Amphipora* are concentrated on a bedding plane in the lower part of this limestone. A similar occurrence of stromatoporoids was noted at Keidle's Bluff.

Farther north the surface of the Cedar Valley Limestone has greater relief and the dolomitized Nora Member is correspondingly thicker where it fills shallow depressions. The equivalent of the bedding plane with the single layer of stromatoporoids observed at Keidle's Bluff and at Baker's Bluff is here a distinct bed from 0.5 foot to one foot in thickness. In the region of Mason City the equivalent bed is a prominent biostrome up to 5.5 feet in thickness (see third traverse). These conditions are observed in a quarry section half a mile northwest of Rock Falls (appendix I, section 20).

The largest amount of exposed relief on the top of the Cedar Valley Limestone is observed in a quarry along the west bank of

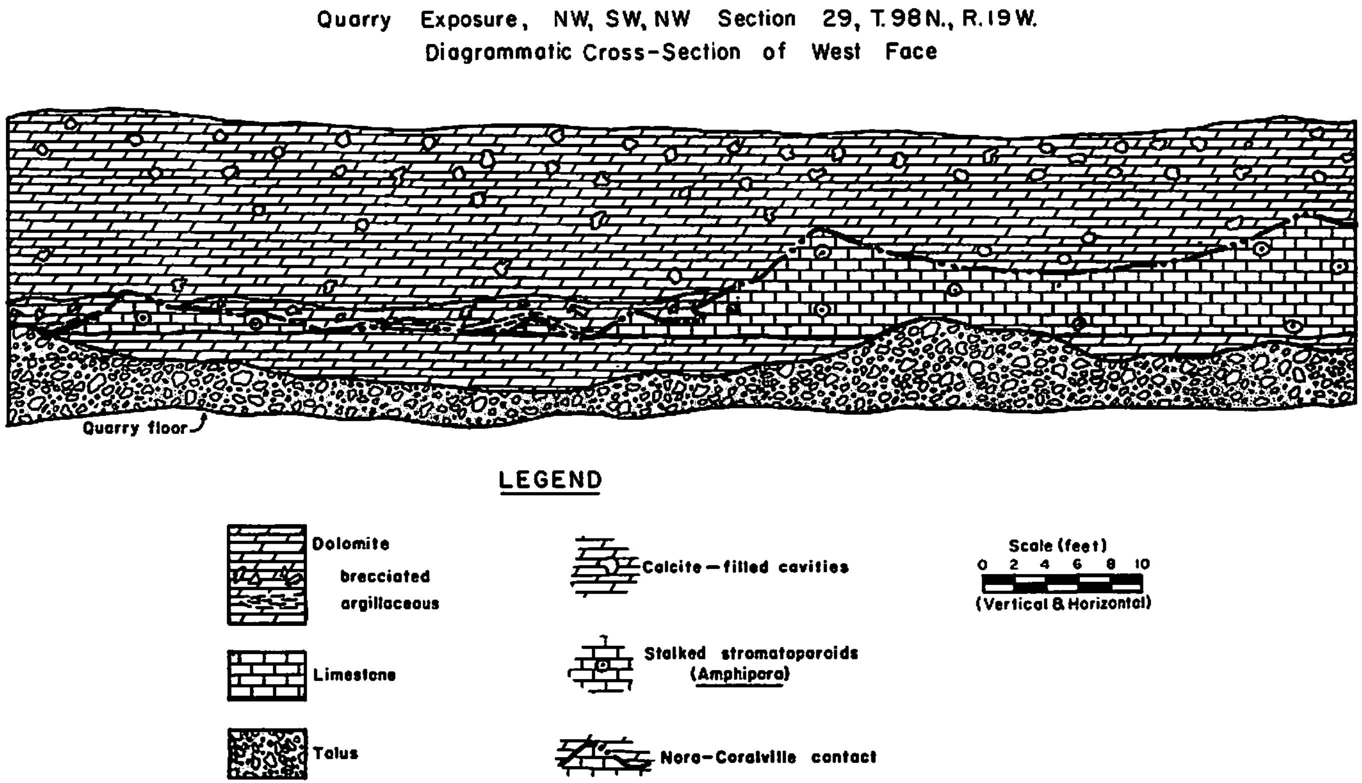


Figure 14. Relief on upper surface of the Cedar Valley Limestone; note brecciated zone at base of Nora Member.

the Shell Rock River two miles north of Plymouth (appendix I, section 21). Here the relief is seven feet; consequently, the dolomitized Nora is highly variable in thickness. Details of variations in thicknesses of beds are depicted in figure 14.

Significant exposures of Shell Rock-Cedar Valley strata are limited north of the above-described section. Drill cuttings from southeastern Worth County show that the Cedar Valley Limestone is the bedrock and it is composed of either lithographic limestone or the underlying dolomite. An example of the former condition is given in appendix II, W-18062. Farther north, along the Shell Rock River east of Kensett and in the vicinity of Northwood, outliers of the lower biostrome of the Nora Member form the only remaining portion of the Shell Rock Formation. In addition to subspherical stromatoporoids numerous specimens of *Trigonotreta shellrockensis*, high- and low-spired gastropods, and charophyte oogonia (*Trochiliscus* sp.) occur in the biostrome at these locations. The subjacent beds are those of the Cedar Valley Limestone, dolomite at a few locations and sublithographic limestone at other locations.

Third Traverse —

Stratigraphy in the Region of Portland and to the Northwest Along the Winnebago River

There are no exposures of Shell Rock-Cedar Valley strata between Nora Springs and Portland. Only portions of the Lime Creek Formation are exposed on either side of the divide that separates the drainage basin of the Shell Rock River from the Winnebago River (fig. 15). The reader will recall that beds of the Nora Member lie unconformably upon the Cedar Valley Limestone in the vicinity of Rock Falls. This same stratigraphic relationship is observed at Portland, and, as is the case north of Nora Springs, the exact geographic termination of the Rock Grove and Mason City Members is unknown (pl. I). A core (appendix III, core 2) was drilled one mile north and 1¾ miles east of Portland in an attempt to more accurately define the termination of these members and to obtain another control point where the contact of the Juniper Hill Shale with the Shell Rock Formation could be identified. Examination of the core revealed that Pleistocene deposits lie unconformably upon the Nora Member and that, in turn, the Nora Member is unconformably in

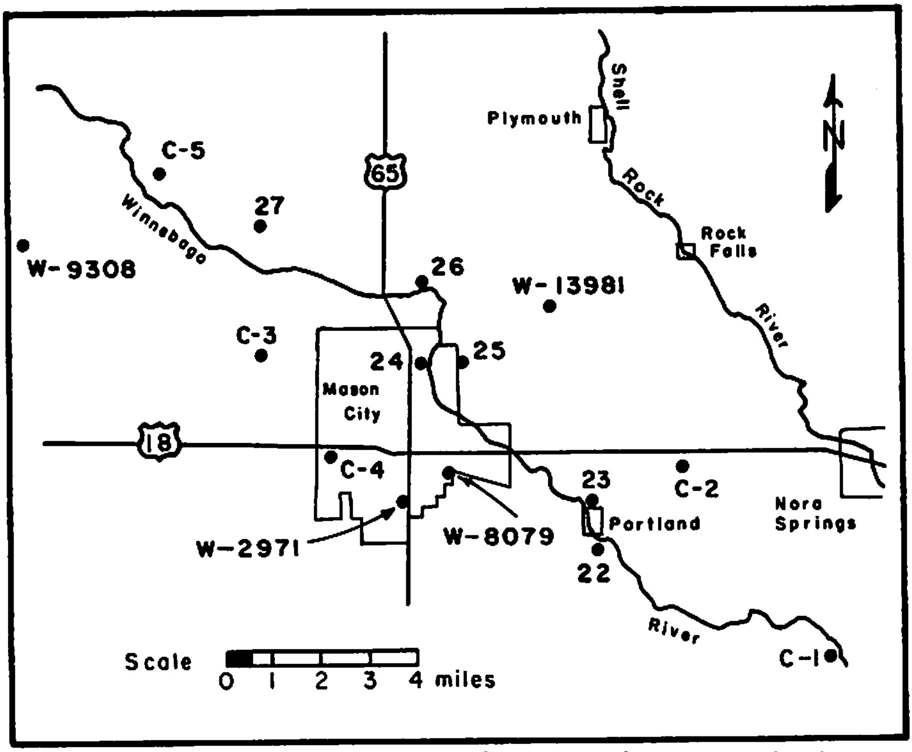


Figure 15. Route of traverse 3; numbers 22-27 refer to section descriptions in appendix I; W-8079, W-13981, etc. refer to well log descriptions in appendix II; C-1, C-2, etc. refer to core descriptions in appendix III.

contact with Cedar Valley strata. Presumably, Pleistocene erosion has removed any beds of the Lime Creek Formation which may have been deposited here. The upper tabular stromatoporoid biostrome of the Nora is conspicuous in the core. The lower beds of the Nora occur as dolomitized beds similar to those in exposures northwest of Nora Springs. The underlying Cedar Valley beds also are dolomitized.

The contact of the Nora Member with the Cedar Valley Limestone is exposed in the McEachran quarry half a mile south of Portland (appendix I, section 22). As in the core mentioned above, the upper tabular stromatoporoid biostrome of the Nora Member is conspicuous. The underlying dark-colored dolomite is the equivalent of the middle argillaceous unit or the lower stromatoporoid biostrome of the Nora. Relief on the top of the Cedar Valley Limestone is about four feet, and at a few locations in the quarry the beds are sharply truncated. This limestone is the interval that, in the river exposures near the quarry, Belan-

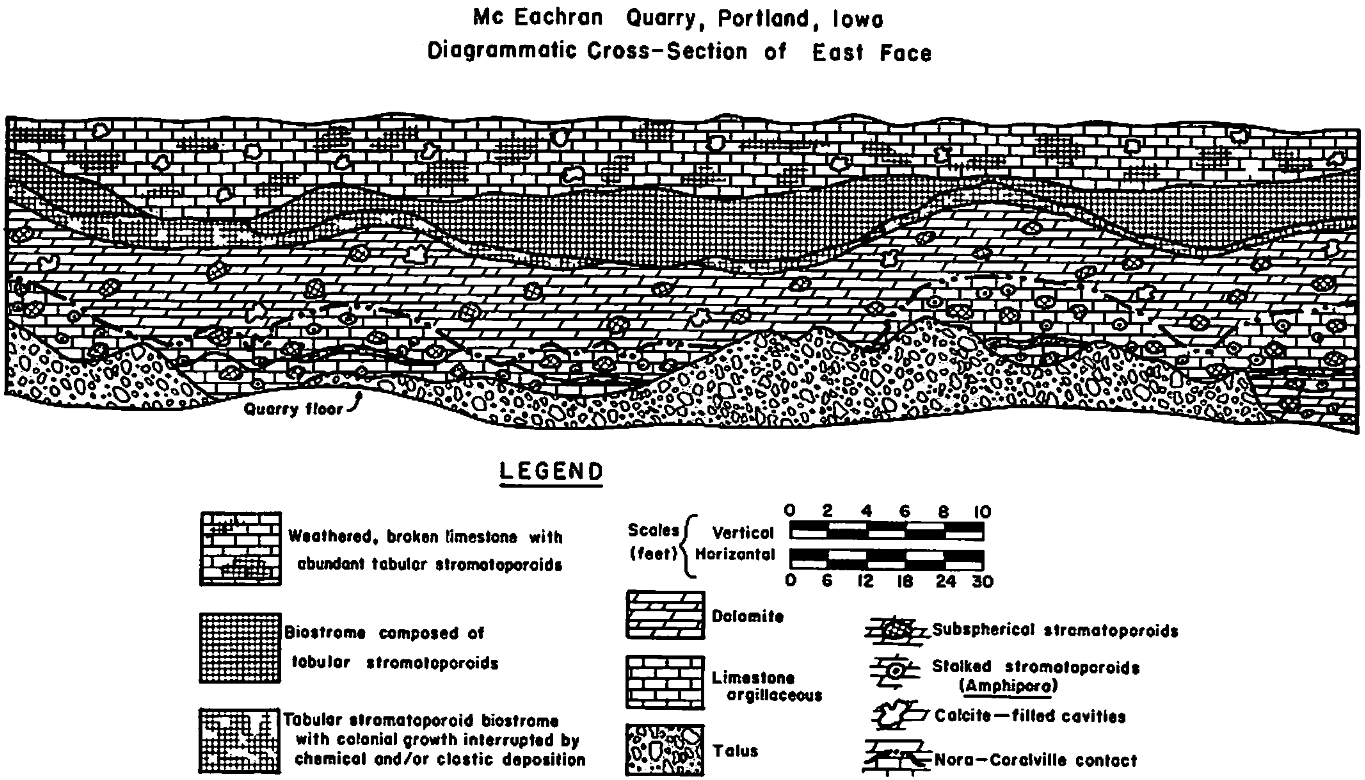


Figure 16. Irregular contact of Nora Member with the Cedar Valley Limestone.

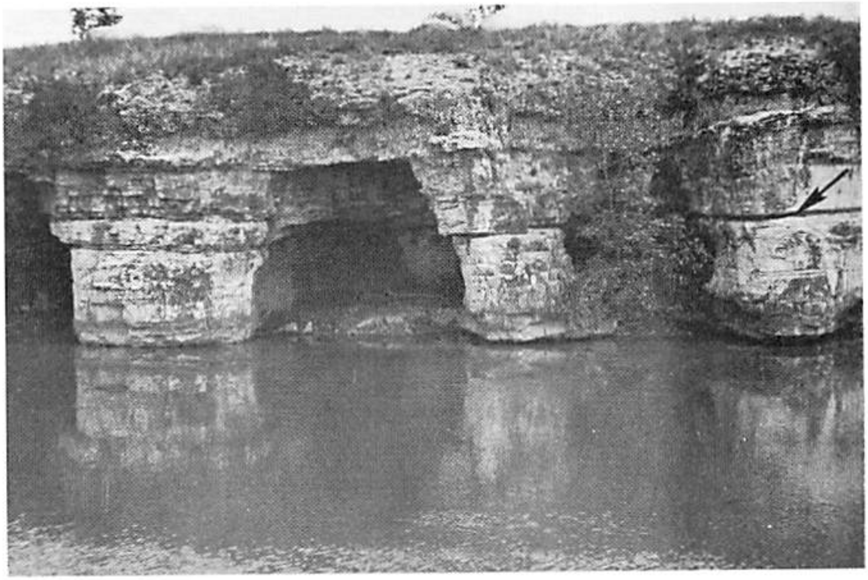


Figure 17. Caverns formed within the Nora Member and Cedar Valley Limestone along the Winnebago River; in this photograph the cavern ceilings are at the base of the tabular stromatoporoid biostrome of the Nora Member. The bedding plane occurrence of small subspherical stromatoporoids and *Amphipora* within the Cedar Valley Limestone is marked by arrow.

ski correlated as the equivalent of the Rock Grove Member, and he correlated the underlying dolomite with the Mason City Member. Once again, a bedding plane occurrence of small subspherical stromatoporoids similar to that in the equivalent stratigraphic position in the Rock Falls area (second traverse) is present in this quarry. The variation in bed thicknesses and the irregular Shell Rock-Cedar Valley contact is illustrated in figure 16.

East of the McEachran quarry, on the east bank of the Winnebago River, a series of shallow caverns has been eroded within the Cedar Valley Limestone (fig. 17). The ceiling of each cavern occurs at the base of the upper tabular stromatoporoid biostrome or within the lower part of the Nora Member; the floors of the caverns are near the base of the lithographic limestone bed of the Cedar Valley. A continuous weak re-entrant within the limestone marks the position of the bedding plane occurrence of small subspherical stromatoporoids and *Amphipora*, again, the same bedding plane feature that is present throughout the Rock Falls region.

The unconformable contact of the Juniper Hill Shale with the Nora Member is exposed in a smaller quarry opening about one-fourth mile west of the McEachran quarry. The contact is marked by a concentration of fish teeth (*Ptyctodus calceolus*) within the base of the Juniper Hill Shale, and pyrite is concentrated within the upper part of the Nora Member. This fish tooth zone has been exposed on the north side of U. S. Highway 18 on the west side of the Winnebago River in Mason City, and is present in cores drilled near the northwestern and southwestern corporate limits of Mason City (appendix III, cores 3, 4).

A section similar to that in the McEachran quarry is exposed on the east bank of the Winnebago River half a mile northwest of Portland. The continuity of the bedding plane occurrence of subspherical stromatoporoids and *Amphipora* is observable at this location also (appendix I, section 23).

Shales and carbonates of the Lime Creek Formation form the bedrock in the southern and western parts of Mason City. Consequently, cores and drill cuttings provide the only data on stratigraphically lower beds in this area. These data show significant changes both in the Nora Member and in the Cedar Valley Limestone as compared with the sequence of rocks in the Portland sections described above. The Nora is more dolomitic in southwestern Mason City, but the tabular stromatoporoids of the upper biostrome still are recognizable (appendix II, W-8079; appendix III, core 4). The bedding plane concentration of subspherical stromatoporoids and *Amphipora* in the limestone of the Cedar Valley, as observed at Rock Falls and Portland, is here a prominent biostrome and is recognizable throughout the region of Mason City. This is the biostrome that Belanski (p. 369) correlated as the equivalent of the lower stromatoporoid biostrome of the Nora Member. The limestone interval of the Cedar Valley generally is thicker in the Mason City region than it is near Portland (appendix II, W-8079, W-2971).

Natural exposures of the upper tabular stromatoporoid biostrome of the Nora Member are rare in the Mason City area. Usually it is the biostrome in the Cedar Valley Limestone, composed of subspherical stromatoporoids and *Amphipora*, that forms the uppermost exposed bed along the streams. Beds of the Nora, and the underlying Cedar Valley Limestone, are exposed in an artificial drainage cut in the northern part of Mason City (fig. 18; appendix I, section 24). The upper stromatoporoid biostrome of the Nora is well developed and is underlain by a

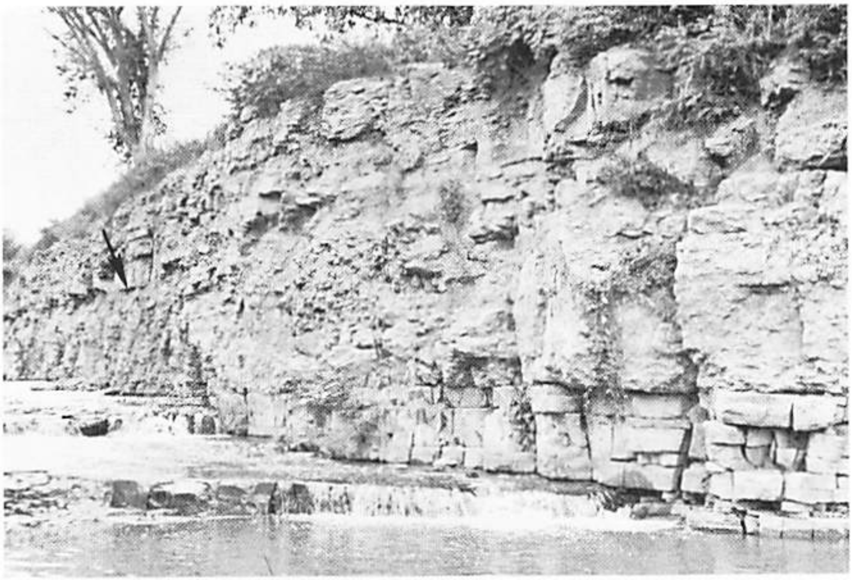


Figure 18. Contact of Nora Member with the Cedar Valley Limestone (arrow), northern part of Mason City. (See graphic column, appendix I, section 22).

dolomite bed which is the equivalent of the middle argillaceous unit of the Nora Member. A biostrome that is composed dominantly of subspherical stromatoporoids forms the top of the Cedar Valley Limestone at this location. Through common usage, the underlying lithographic limestone beds locally are referred to as the "cement ledge". These are the source beds for the manufacture of portland cement in Mason City. The underlying dolomite beds (not exposed) locally are referred to as the "Mason City beds". A similar section occurs in a quarry one mile east of the drainage cut where the dolomite beneath the Cedar Valley Limestone is exposed (appendix I, section 25). Subspherical stromatoporoids are scattered throughout this dolomite and have been calcitized and/or dolomitized; the morphologic structures of many specimens are recognizable even where they have been dolomitized. "Vermicular" porosity in this dolomite is caused by calcitization and solution of fragmented *Amphipora* stalks. A stratigraphically higher bed of the Cedar Valley Limestone is exposed in a quarry two miles northwest of the last-mentioned section (appendix I, section 26). This bed lies above the biostrome of subspherical stromatoporoids and *Amphipora*. An interval equivalent to this bed, but of greater thickness, occurs northwest of Mason City and will be discussed

Figure 19. Biostrome of subspherical stromatoporoids and *Amphipora* within the Cedar Valley Limestone.

later. The stromatoporoid biostrome in the Cedar Valley Limestone at this location is shown in figure 19. The conspicuous "vermicular" porosity in the lower dolomite beds of the Cedar Valley Limestone is the result of calcitization and solution of fragmented *Amphipora* stalks.

Beds of the Lime Creek Formation that may have been deposited throughout the northeastern portion of Mason City have been removed by Pleistocene erosion. Drill cuttings three miles east of the last-mentioned quarry indicate a regional continuity of Shell Rock Formation-Cedar Valley Limestone lithologies between the Mason City and Rock Falls areas. The cuttings (appendix II, W-13981) show Juniper Hill Shale lying on dolomitized Nora(?) which is underlain in turn by beds of the "cement ledge" (Cedar Valley of this report, Rock Grove of Belanski) and the "Mason City beds" (Cedar Valley of this report, Mason City of Belanski).

Only a few control points are available for examining Shell Rock-Cedar Valley relationships northwest of Mason City. The most complete sections are exposed in quarries operated by the portland cement industries of Mason City. A facies change in the Nora Member and zones of incomplete dolomitization within the Cedar Valley Limestone are apparent in the Lehigh Portland Cement Company quarry (appendix I, section 27). The Nora Member is composed of finely crystalline limestone with a fauna that includes the following: *Cyrtospirifer whitneyi, Aulopora,* high- and low-spired gastropods, charophyte oogonia (*Trochiliscus* sp.), *Atrypa,* small subspherical stromatoporoids, and rugose corals. Crinoid fragments are abundant, and one orthoceraconic cephalopod was found. C. *whitneyi* always has been recognized as an index of Upper Devonian (G.A. Cooper, written communication, March 25, 1966). This fauna is very similar to that found in the Nora Member near Kensett (second traverse), except that subspherical stromatoporoids are more abundant near Kensett and *Trigonotreta shellrockensis* is the brachiopod found near Kensett rather than C. *whitneyi.* The portion of the Nora Member present in this quarry (preserved only along the south face) is correlated as a facies equivalent of the lower stromatoporoid biostrome. The middle argillaceous beds and the upper tabular stromatoporoid biostrome of the Nora Member are absent, possibly the result of Pleistocene erosion. However, non-deposition or pre-Juniper Hill erosion may best explain their absence because irregular large pockets of Juniper Hill Shale occur as stratigraphic leak in the underlying Cedar Valley. The dolomite beds beneath the Nora Member are correlated with the Cedar Valley Limestone. These beds contain lenses of unaltered lithographic limestone similar to the limestone beds that are present in the lower part of the quarry. The lower beds are equivalent to the "cement ledge" in exposures in the Mason City area, but the interval is much thicker at this locality. There are two subspherical stromatoporoid biostromes within the "cement ledge". The lower biostrome is more persistent and is probably the equivalent of the biostrome immediately above the "cement ledge" in the northeast part of Mason City. The dolomite in the floor of the quarry is the equivalent of the "Mason City beds" in quarries and natural exposures in the region of Mason City.

The facies of the Nora Member observed in the Lehigh quarry is exposed at several locations along the Winnebago River farther northwest. At the Lincoln Mill site, two miles northwest of the Lehigh quarry, *Cyrtospirifer whitneyi* is found in abundance along a bedding plane. Most of the other fossils that occur in the Nora Member at the Lehigh quarry are present at this location.

A series of five cores drilled half a mile north of the Lincoln Mill site contained a section comparable to that of the Lehigh quarry. A log of the deepest core is given in appendix III, core 5. The uppermost bed at this location is a dolomite interval that is not present at the Lehigh quarry and is probably equivalent to the middle argillaceous bed of the Nora Member. The underlying limestone is similar lithologically to that of the Nora Member in the Lehigh quarry and the same fauna is present.

The few exposures in the area of Fertile and Hanlontown, Iowa (southwestern Worth County) may be outliers of Shell Rock strata. These beds have been dolomitized and their true relationship with beds of the Shell Rock Formation or Cedar Valley Limestone has not been established. A deep quarry was opened 1½ miles east of Fertile, but the author was able to observe only the upper few feet of section which may be dolomitized beds of the Nora Member. Like most quarries in northern Iowa, this quarry is filled with water when not operated, and the main quarry face never was exposed during the study reported here.

Subsurface data south of Fertile demonstrate that the Juniper Hill Shale lies unconformably above the Cedar Valley Limestone with no intervening Shell Rock strata. Cuttings from a well three miles southwest of the Lincoln Mill site indicate that the limestone of the "cement ledge" lies immediately beneath the Juniper Hill Shale (appendix II, W-9308). Either the limestone of the "cement ledge" or the underlying dolomite occur beneath the Juniper Hill Shale at all other subsurface control points farther south and to the southeast as far as the town of Rockwell. Thus, the maximum westerly extent of the Shell Rock Formation lies along a northwest-southeast trending line from just west of Fertile to the town of Rockwell in south-central Cerro Gordo County, and to the south of Greene in northern Butler County. (See figs. 4, 5, 6).

DEPOSITIONAL ENVIRONMENT OF SHELL ROCK SEDIMENTS

Beds of the Shell Rock Formation were deposited in a relatively small, shallow basin on the eroded surface of the Cedar Valley Limestone. This basin trended northwest-southeast and extended over an area at least 65 miles in length and 25 miles in width. Deposition within the basin during Shell Rock time probably extended from near the Iowa-Minnesota state line in north-central Worth County, southeasterly to northeastern Butler County. Presumably, the Shell Rock sea encroached upon the Cedar Valley from the west-northwest. (See discussion of faunal relationships, p. 4).

Subaerial erosion over most of the Cedar Valley surface probably was continuous in eastern and southeastern Iowa during much of Shell Rock time. The State Quarry Limestone in northern Johnson County (Upper Devonian beds which occur above the Middle Devonian Cedar Valley Limestone) may represent another localized interval of deposition contemporaneous with at least part of the Shell Rock Formation. Furnish and others (1969, p. 12) state that "the conodont fauna of the State Quarry is younger than that of the bulk of the Cedar Valley and older than that of the Rock Grove Member of the Shell Rock Formation of north-central Iowa".

Mason City Member

Initial deposits of the Mason City Member were thin clay seams and lime muds. The latter subsequently were dolomitized. The areas of greatest accumulation of these deposits were sufficiently shallow to provide an environment favorable for the development of a biostrome of subspherical stromatoporoids and corals. Many of the corals and stromatoporoids show evidence of slight fragmentation and abrasion indicative of growth in shallow water subjected to wave action. Several authors (Lecompte, 1954; Andrichuk, 1958; Klovan, 1964; and Mountjoy, 1965) already have interpreted a highly agitated environment for these massive, subspherical or globular stromatoporoids.

A prominent discontinuity surface was developed contemporaneously with or immediately after the growth of the biostrome. This surface probably was formed within the intertidal to slightly above tide zone after a slight regression of shallow water from a nearly level plain of carbonate sediments (Koch and Strimple, 1968, p. 10). This horizon marks a discontinuity surface for which no major time break is involved but a definite break in sedimentation is evident. Slight submergence of this surface provided an environment favorable for the growth of cystoids, edrioasteriods and stolonal-branching corals and bryozoans. A sudden influx of mud mixed with fine carbonate detritus ended this period of organic growth.

Gastropods, subspherical stromatoporoids, corals, crinoids, and brachiopods were abundant during the next period of carbonate deposition. Strong wave and current action generally resulted in fragmentation and abrasion of the hard parts of these organisms. Limestones rich in crinoid ossicles, and which contain a few fragmented subspherical stromatoporoids characterize most of the remaining Mason City Member. Localized rapid deposition of lime mud is evidenced by the preservation of crinoid crowns with long stem segments (Strimple and Levorson, 1969). Charophyte oogonia, probably washed outward from the intertidal zone, also are present. Near the end of Mason City time conditions became favorable again for the establishment of a fauna rich in corals and subspherical stromatoporoids, but not to the extent of developing a biostromal phase.

Rock Grove Member

The Rock Grove Member is characterized by dominantly argillaceous beds. A period of somewhat unstable depositional conditions in slightly deeper water is indicated by deposits of thin-bedded, relatively non-fossiliferous argillaceous limestone separated by shale seams and partings. Bottom dwelling organisms that include ostracodes and pelecypods, and a few fish plates are the only fossils in these beds. Subsequent deposition in a more uniform environment is evidenced by beds of massive, argillaceous, moderately fossiliferous limestone in the middle of this member. A sublittoral environment of intermediate depth is suggested by the abundance of brachiopods. An increase in the supply of terrigenous mud mixed with fine carbonate detritus marked the deposition of beds of calcareous clay and lime mud throughout the area of the Rock Grove Member. The resultant calcareous shales and argillaceous limestones are barren of fossils except for the occurrence of a few conodonts (Anderson, 1964, 1969).

Shallower depositional environments for the upper beds of the Rock Grove Member followed the gradual reduction in basin relief by the continued influx of terrigenous mud. Lime sands were deposited in agitated water and were spread over the shallow shelf. Cross-bedding is a common feature in these beds. A decrease in wave activity brought conditions in which brachiopods flourished (principally *Platyrachella* and *Schizophoria*). Localized areas of echinoderm growth are evidenced by crinoid ossicles and a few cystoid calices in the east-central part of the basin. These carbonate beds subsequently were dolomitized. By the end of Rock Grove deposition the basin was reduced to a broad, relatively shallow shelf.

Nora Member

Galloway and St. Jean (1957, p. 69) suggested that clear, warm water, and abundant food and carbonate material were optimum conditions for the growth of stromatoporoids. Intervals of widely spaced laminae indicate growth under optimum conditions whereas intervals of closely spaced laminae indicate adverse conditions. Certainly, optimum conditions for stromatoporoid growth prevailed during the first stage of Nora deposition. Colonies of tabular stromatoporoids probably converged from many centers of growth and developed into a massive biostrome. Deposits of the Nora Member covered a larger area than did deposits of the lower members. The larger depositional area of the Nora Member is interpreted as a response to a transgressive phase of the Shell Rock sea. An ecologic change toward the northern area of deposition is suggested by a gradual replacement of the tabular stromatoporoids with subspherical stromatoporoids and stalks of *Amphipora*. A highly agitated depositional environment has already been mentioned for the subspherical stromatoporoids. As the stalks of *Amphipora* are broken and are partly rounded they must have been subjected to some erosion and probably transportation before deposition, also indicative of a shallow, more turbulent environment.

A regressive phase ended the period of organic growth. Terrigenous muds were deposited upon the biostrome and were mixed with carbonate detritus in localized areas. The resultant shales and argillaceous carbonates separate the lower and upper stromatoporoid biostromes.

The upper tabular stromatoporoid biostrome of the Nora Member was deposited during the final transgressive phase of the Shell Rock sea. Tabular stromatoporoids spread over even a larger area than did those in the lower Nora biostrome. Periodic strong wave activity near the western limit of the biostrome is indicated by intervals of slightly broken stromatoporoids with carbonate deposition interrupting colonial growth.

The upper tabular stromatoporoid biostrome of the Nora Member completed the sequence of Shell Rock deposition. Except for perhaps a slight amount of subaerial exposure, this unit was affected very little in the northern area before the advance of the Lime Creek sea. In contrast, subsurface data suggest considerable erosion in the southern area where the Juniper Hill Shale lies directly upon the lower stromatoporoid biostrome.

PETROGRAPHIC NOTES

General Statement

Brief descriptions of some petrographic features of Shell Rock and Cedar Valley strata are presented here. A comprehensive petrologic study of these units has not been undertaken. The variations in lithology and the diagenetic problems within these beds constitute a major research subject in themselves.

Photomicrographs shown in plates II-III illustrate selected petrologic features of the Shell Rock Formation and of the "cement ledge" and "Mason City beds", both of which formerly were correlated with the Shell Rock Formation and are herein correlated with the Coralville Member of the Cedar Valley Limestone.

"Mason City beds"

The thin section examined from this interval was prepared from a sample taken near the middle of the "Mason City beds" in Weaver's quarry (appendix I, section 26). The rock is dolomite and the dolomite crystals are subhedral to euhedral. Individual crystals range from 125 to 325 microns in size and average about 215 microns. The crystals are non-uniformly argillaceous and many exhibit clear zonal rims (pl. II A). The argillaceous centers suggest that the dolomite was derived by replacement of argillaceous micrite. "Vermicular" porosity in the rock is believed to be caused by solution of broken *Amphipora* stalks. The pores occur as tubular openings which average 1.5mm in diameter and range from one-half inch to three inches in length. They are oriented parallel to the bedding.

"Cement ledge"

The limestone in beds of the "cement ledge" is composed of slightly argillaceous micrite. Hand specimens generally show the limestone to be variably pelletiferous, and specimens that appear to be homogeneous micrite contain ghost-outlines of pellets in thin section (pl. II B). Void-filling sparry calcite is common. Fractures with no apparent preferred orientation are sealed with sparry calcite.

Fossil allochems generally are limited to fragments of *Amphipora*, ostracode valves, and a few brachiopod fragments. The discontinuous, irregular chambers of *Amphipora* are filled with sparry calcite or argillaceous micrite (pl. II C). Whole and fragmented ostracode valves are common in the Rock Falls and eastern Mason City areas. Northwest of Mason City ostracode valves are more abundant and less fragmented.

Calcispheres are very conspicuous in these limestone beds. The typical calcisphere is a spherical chamber from 110 to 175 microns in diameter with a coarse mosaic of drusy calcite within the chamber and a very thin, dark microcrystalline wall that probably resulted from recrystallization of an original hyaline wall. Rarely, a calcisphere is observed which possesses a thick wall composed of radiating calcite spines or prisms (pl. II B, D). The calcisphere structures probably are the remains of some form of plant spore or reproductive body (Stanton, 1963).

Authigenic dolomite crystals generally are present throughout the micrite but they are more abundant in the lower beds. The crystals range in size from 105 to 575 microns and average about 260 microns. They exhibit unit extinction, are non-uniformly argillaceous, and represent replacement of micrite (pl. II E). The dolomite crystals encroach upon *Amphipora* in a few cases and fill portions of their outer chambers. Calcitization of former dolomite crystals in the limestone has occurred at a number of locations. An outstanding occurrence of this pseudomorphic phenomenon is observed in the limestone from the Foster's Mill quarry section (fig. 14; appendix I, section 21). Crystal faces of the former dolomite crystals are retained, but the mass of each is now composed of randomly oriented anhedral calcite (pl. II F).

Beds of the "cement ledge" have been more completely dolomitized at locations in and south of Rock Falls. Only a few lenses and small, irregular patches of limestone remain unreplaced by the dolomite (pl. III A). Specimens of *Amphipora* that occur at a dolomite-limestone contact show very little to no dolomitization. Specimens that occur wholly within the dolomite exhibit scattered dolomite crystals or have been completely dolomitized. Many specimens have been calcitized and dissolved, and remain only as external molds of *Amphipora* stalks. Stylolite sutures are very abundant. Organic-rich clay is disseminated throughout the limestone and is conspicuous around dolomite grains. The organic content suggests deposition under somewhat restricted water conditions.

Mason City Member

Thin sections were prepared only from the limestone upon which the discontinuity surface is developed and from the overlying dolomite. The limestone is a biomicrite with fossil allochems that include brachiopods, ostracodes, crinoid stem segments and gastropods embedded in micrite with a minor amount of microspar. *Solenopora* has been identified by J. L. Wray (Marathon Oil Co., written communication, Dec. 5, 1967). Discontinuous micro-fractures are healed with calcite. Euhedral dolomite fills shallow borings in the limestone and deeper borings contain subhedral to euhedral dolomite in the upper part and sparry calcite in the lower part (pl. III B). Dolomite above the limestone generally is finer grained than that which fills the borings and is euhedral to subhedral with an argillaceous matrix and minor sparry calcite.

Rock Grove Member

The thin section examined from this interval was prepared from a sample of the thin-bedded limestone unit at the base of the member in the Baumgardner Mill section (appendix I section 8). Fossil allochems are limited to a few ostracode valves. Questionable calcisphere structures in the limestone are similar to those in the "cement ledge" but they generally lack the conspicuous outer dark wall. These structures are not apparent in hand specimens. Authigenic dolomite euhedra are common and range in size from 80 to 125 microns and average about 90 microns (pl. III C). Discontinuous fractures are sealed with sparry calcite.

Nora Member

Thin sections were not prepared from stromatoporoids in the biostromes of the Nora. Only the dolomitic portion of the Nora in the north-central portion of the basin and the northern limestone facies were petrographically studied.

The basal Nora in the Foster Mill quarry section (appendix I, section 21) is a breccia. Breccia fragments vary from ¼mm to 20mm in size and are composed of subhedral, calcitized dolomite crystals from 65 to 110 microns in size. The matrix consists of euhedral, argillaceous, variably calcitized dolomite crystals from 125 to 550 microns in size and average about 340 microns. They exhibit wide, clear zonal rims, some of which have been partially calcitized (pl. III D). Stylolite sutures transect both the breccia fragments and the matrix.

The northern limestone facies of the Nora is composed of slightly argillaceous micrite. Fossil allochems are abundant (see description of fossils, p. 39) and show little or no alteration. Fossils are more fragmented in the most northwesterly area of exposure, suggestive of deposition in an environment of stronger wave or current action (pl. III E,F).

PLATES II - III

PHOTOMICROGRAPHS

EXPLANATION OF PLATE II

A. "Mason City beds". Dolomite crystals(D) that retain argillaceous content of original micrite; many crystals show clear zonal rims(R). Appendix I, section 26, unit 1. Plane polarized light, 30x.

B. "Cement ledge". Pellets(P) in micrite, and calcispheres(C) with dark, microcrystalline walls. Appendix I, section 27, unit 2. Plane polarized light, 75x.

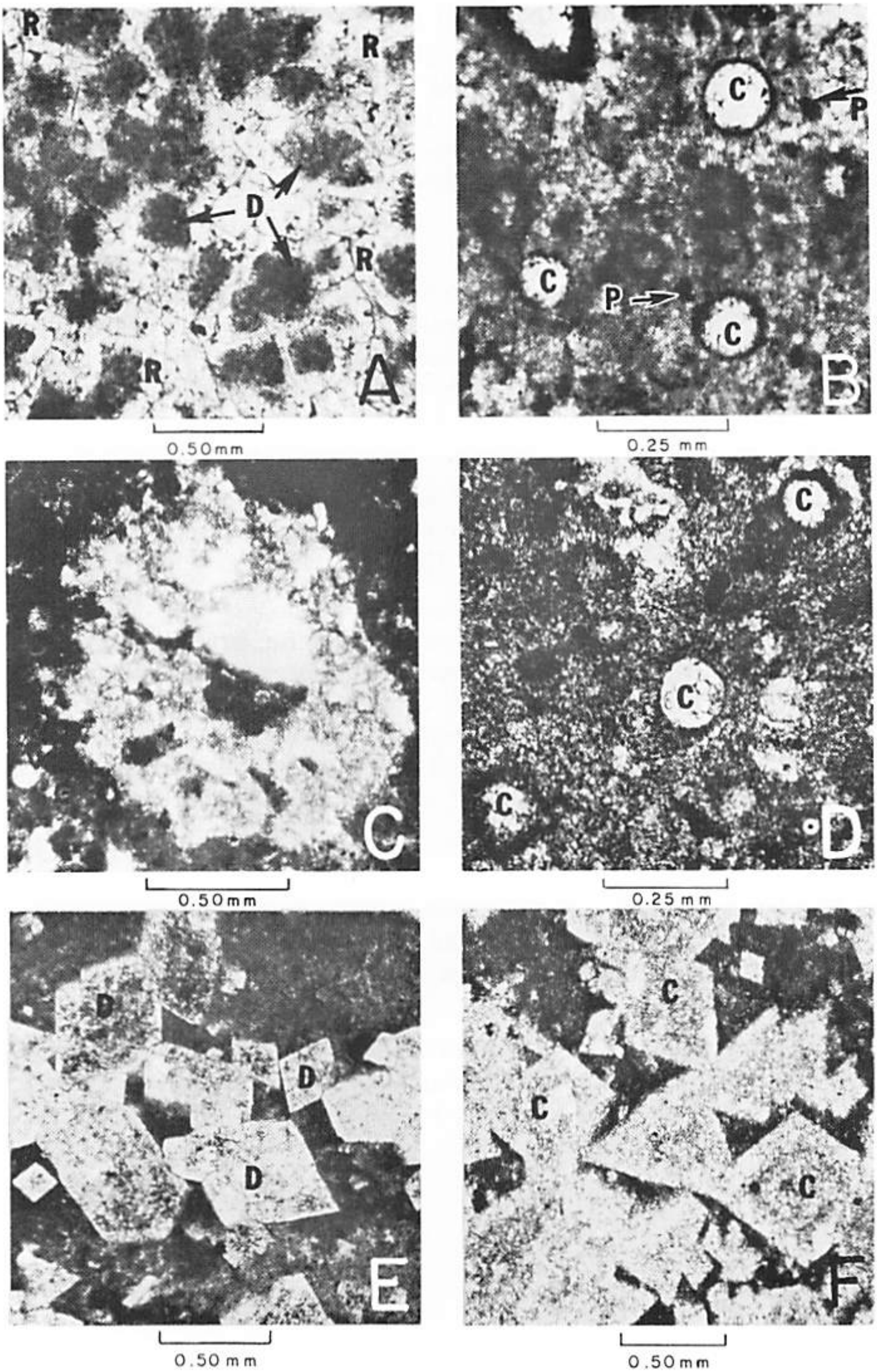
C. "Cement ledge". Cross section of *Amphipora;* central canal and vesicles in lower one-half of specimen are filled with micrite, upper one-half with calcite. Creek exposure, SE cor. SW¼, NE¼, Sec. 21, T. 97 N., R. 19 W., Cerro Gordo County, Iowa. Plane polarized light, 40x.

D. "Cement ledge". Calcispheres(C) in pelletal micrite; specimen at lower left shows greater recrystallization. Location same as photograph B, unit 6. Plane polarized light, 75x.

E. "Cement ledge". Authigenic dolomite(D) in micrite. Location same as photograph A, unit 2. Plane polarized light, 30x.

F. "Cement ledge". Calcitization of dolomite(C); clear areas at crystal margins are unaltered dolomite. Appendix I, section 21, unit 2. Plane polarized light, 30x.

PLATE II


R
R
D
R
R
A
0.50mm
C
P
C
P
C
B
0.25 mm
C
C
0.50mm
C
C
C
D
0.25 mm
D
D
D
E
0.50 mm
C
C
C
F
0.50mm

EXPLANATION OF PLATE III

A. "Cement ledge". Unaltered lense of pelletal micrite (dark) containing calcispheres(C) above dolomite(D). Creek exposure, west side of railroad trestle, NW¼, SE¼ Sec. 27, T. 97 N., R. 19 W., Cerro Gordo County, Iowa. Plane polarized light, 30x.

B. Mason City Member. Micrite(dark) of discontinuity surface in Williams quarry; dark color is caused by finely disseminated pyrite; surface is covered with dolomite(D) and borings into surface filled with dolomite(D). Appendix I, section 7, contact of units 3 and 4. Plane polarized light, 40x.

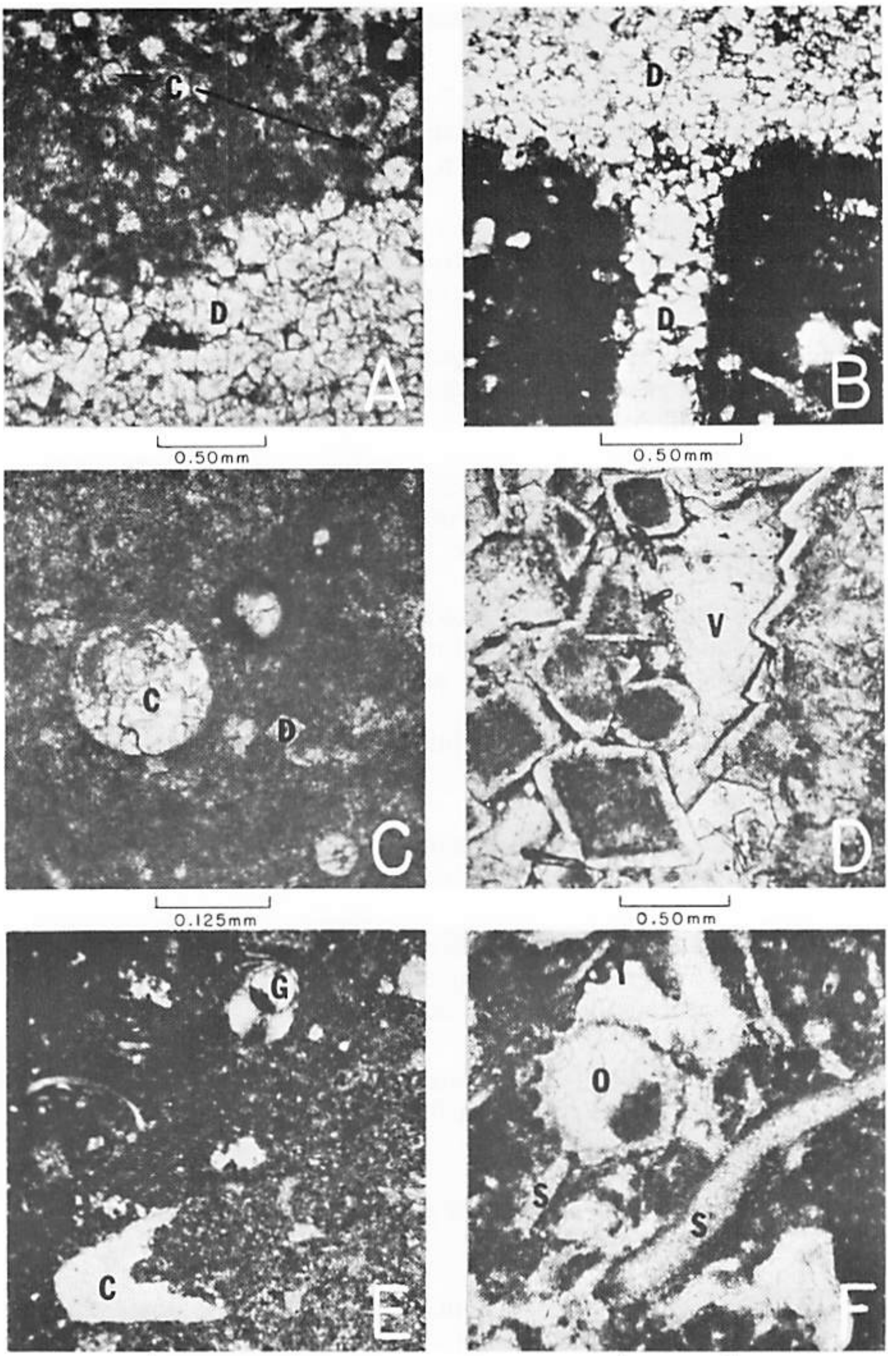
C. Rock Grove Member. Questionable calcispheres(C), and dolomite euhedra(D) in micrite. Appendix I, section 8, unit 11. Plane polarized light, 130x.

D. Nora Member. Calcitization of dolomite; breccia fragment (B) on right side of photograph has been calcitized except for serrate-appearing, clear zonal rims on left side of fragment; nuclei of matrix crystals are almost wholly calcitized(C), but the clear zonal rims are dolomite(D); V, void-filling calcite. Appendix I, section 21, unit 3. Plane polarized light, 30x.

E. Nora Member. Fossiliferous micrite containing gastropods (G), crinoid ossicles(C) and shell fragments (left center). Appendix I, section 27, unit 11. Crossed nicols, 40x.

F. Nora Member. Fossiliferous micrite containing shell fragments(S) and charophyte oogonia(O). Road ditch exposure, SE cor. Sec. 15, T. 99 N., R. 20 W., Worth County, Iowa. Plane polarized light, 30x.

PLATE III



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APPENDICES

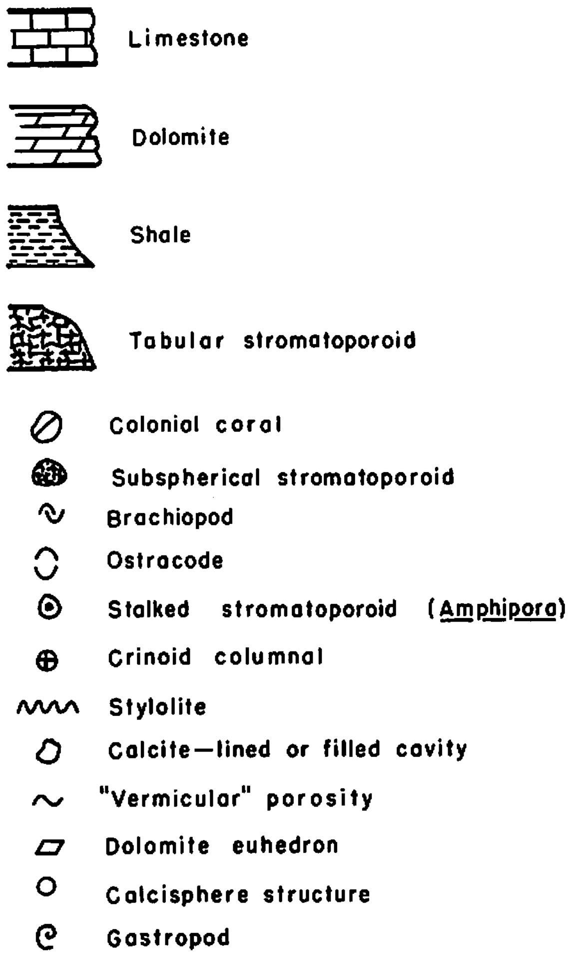
Rock color designations of exposures, drill cuttings, and cores follow the "Rock Color Chart" (National Research Council, 1948) based on the Munsell System. Rock specimens were compared with the color placques using a flourescent lamp with two Champion F15T8/D Daylight bulbs.

APPENDIX I

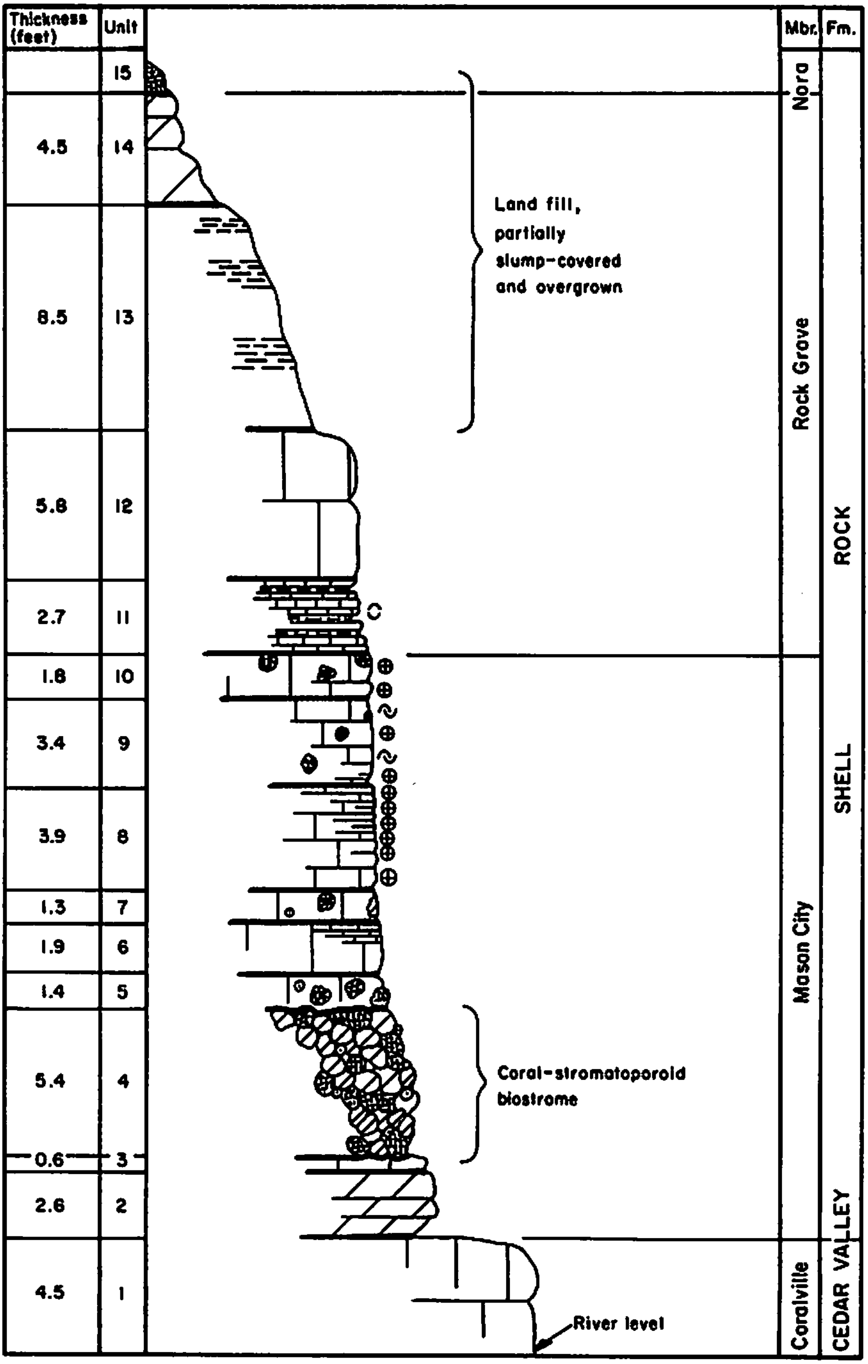
Natural Exposures and Quarries

Sections 1-27

LEGEND FOR GRAPHIC SECTIONS



Section I


Thickness (feet)
Unit
Mbr.
Fm.
15
4.5
14
8.5
13
5.8
12
2.7
11
1.8
10
3.4
9
3.9
8
1.3
7
1.9
6
1.4
5
5.4
4
0.6
3
2.6
2
4.5
1
Land fill, partially slump-covered and overgrown
Coral-stromatoporoid biostrome
River level
Nora
Rock Grove
Mason City
Coralville
ROCK
SHELL
CEDAR VALLEY

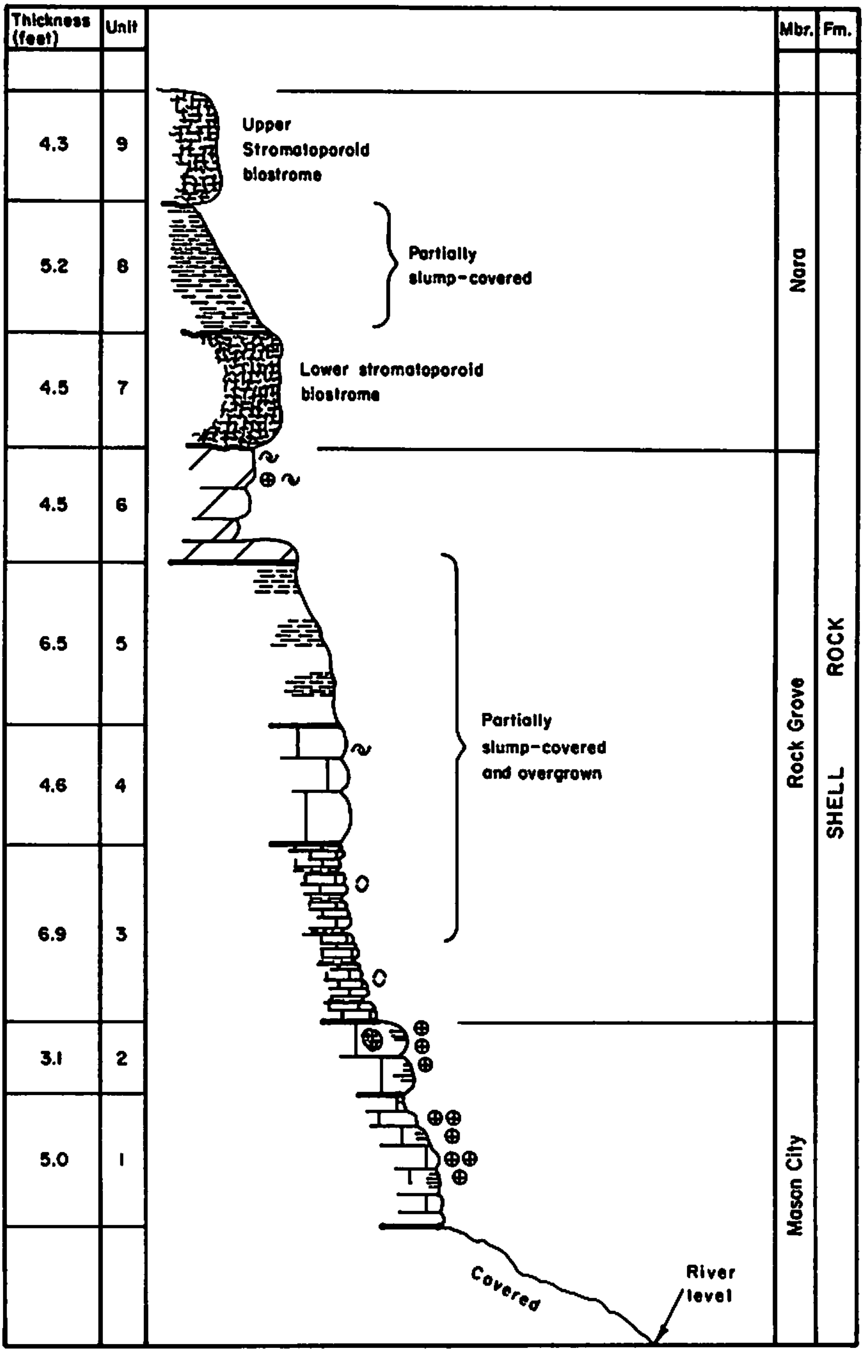
Section 1

TYPE SECTION OF MASON CITY MEMBER

Measured along the east bank of the Shell Rock River, east line of west½, SE¼, Sec. 7, T. 96 N., R. 18 W., Floyd County, Iowa.

Unit	Description	Thickness (feet)
	Devonian System	
	Shell Rock Formation	
	Nora Member	
15	Limestone, very pale yellowish-brown, composed dominantly of colonies of tabular stromatoporoids (*Actinostroma expansum*); iron-stained zones; poorly exposed, partially covered by fill	0.0 - 1.5
	Rock Grove Member	
14	Dolomite, dark yellowish-orange, medium crystalline, subhedral, grading downward to dark yellowish-orange, dolomitic shale; thick-bedded; poorly exposed	4.5
13	Covered interval	8.5
12	Limestone, yellowish-orange, finely crystalline, moderately argillaceous, very dolomitic, slightly silty; "floating" dolomite crystals 1/16 - 1/32mm; broken beds; thick- to massive-bedded; upper surface poorly exposed	5.8
11	Limestone, very pale yellowish-brown, weathering to yellowish-gray; very finely crystalline; contains a few scattered ostracodes; 0.1 to 0.3-foot platy beds separated by shale partings; sharp lower contact	2.7
	Mason City Member	
10	Limestone, grayish-orange to very light olive-gray, weathering to mottled pale yellowish-brown and dark yellowish-orange; finely to very finely crystalline; many subspherical stromatoporoids from 3 to 5 inches in diameter (colored pale yellowish-brown), scattered crinoid columnals, *Athyris* sp. and other brachiopod fragments; thick-bedded	1.8
9	Limestone, pale yellowish-brown, very finely crystalline, mottled with light grayish-orange, slightly dolomitic, moderately argillaceous, finely crystalline limestone; fragmented brachiopods, crinoid columnals, and subspherical stromatoporoids (up to 2 inches in diameter); thick- to massive-bedded, slightly broken; weathers very light olive-gray to moderate yellowish-brown	3.4
8	Limestone, grayish-orange to pale yellowish-brown, finely to very finely crystalline; weakly mottled with light grayish-orange, finely crystalline, slightly argillaceous, dolomitic limestone; crinoid columnals throughout, forming encrinital lenses locally; weathers to moderate yellowish-brown platy beds; thick-bedded	3.9
7	Limestone, very pale-orange, mottled with pale red, finely to very finely crystalline, sub-conchoidal fracture; *Amphipora*, small subspherical stromatoporoids and corals common; rough, pitted upper surface; distinct upper and lower contacts; massive	1.3
6	Limestone, very pale-orange, very finely crystalline to sublithographic; finely laminated in upper part; slightly dolomitic in lower part; distinct upper and lower contacts; thick- to massive-bedded	1.9
5	Limestone, very pale-orange to pale yellowish-brown, finely crystalline; numerous corals, *Amphipora*, and small subspherical stromatoporoids; a very distinctive unit, but merges almost imperceptibly with the underlying biostrome laterally; massive	1.4
4	Limestone biostrome, pale-orange to pale yellowish-brown, composed of slightly broken corals, *Amphipora*, and subspherical stromatoporoids; massive	5.4
3	Limestone, pale yellowish-brown, sublithographic, with scattered lenses and patches of very pale-orange, finely crystalline, argillaceous limestone; scattered calcspar with a few limonite-hematite pseudomorphs as inclusions; zones with "floating" ¼-⅛mm dolomite crystals; ostracodes rare; thin-bedded	0.6
2	Dolomite, pale yellowish-brown to pale-orange, medium crystalline, subhedral to anhedral, calcareous; grades to very pale-orange, sublithographic limestone laterally; distinct upper and lower contacts; thick-bedded	2.6
	Cedar Valley Formation	
	Coralville Member	
1	Limestone, very pale yellowish-brown, lithographic, sharp-edged conchoidal fracture; some scattered calcspar; generally mottled with light yellowish-gray, finely crystalline, argillaceous, dolomitic limestone which weathers readily; hairline fractures common, sealed with calcspar; small corals and subspherical stromatoporoids in upper part; broad undulations on upper surface; exposed to river level	4.5

Section 2


Thickness (feet)
Unit
Mbr.
Fm.
4.3
9
5.2
8
4.5
7
4.5
6
6.5
5
4.6
4
6.9
3
3.1
2
5.0
1
Upper Stromatoporoid biostrome
Partially slump-covered
Lower stromatoporoid biostrome
Partially slump-covered and overgrown
Covered
River level
Nora
Rock Grove
Mason City
SHELL ROCK

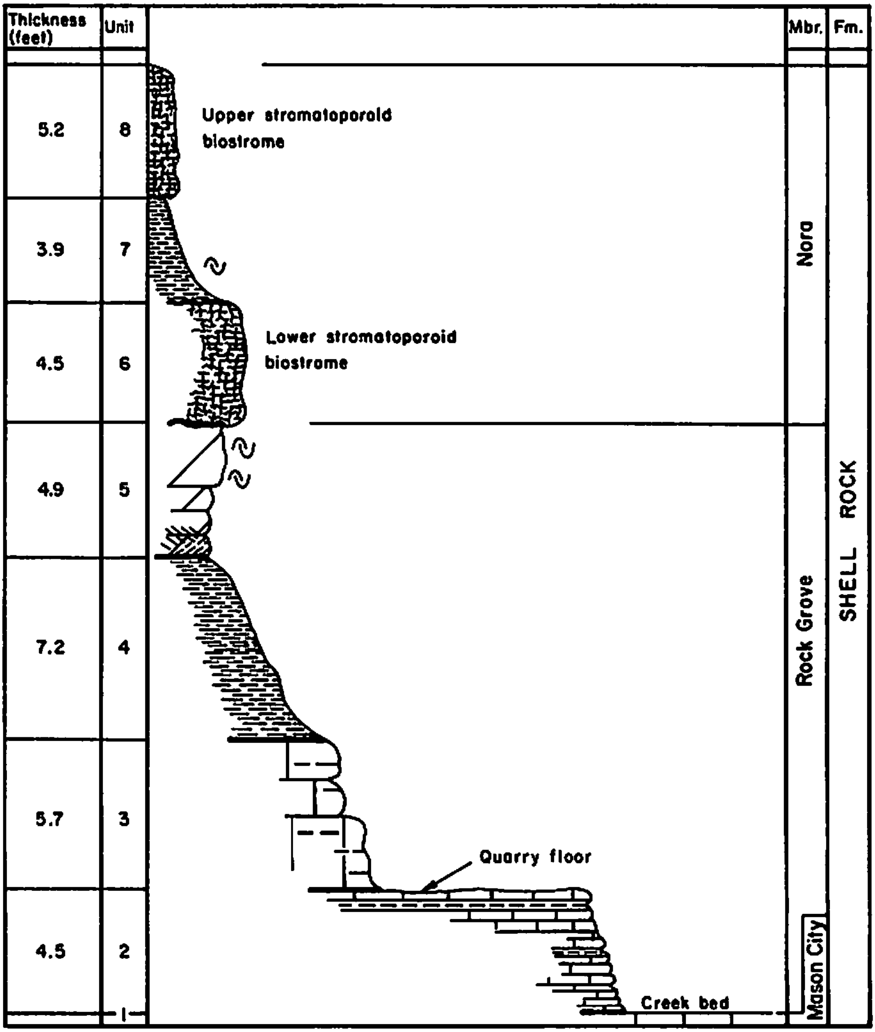
Section 2

TYPE SECTION OF ROCK GROVE MEMBER

Measured along the east bank of the Shell Rock River, in the NW¼, SE¼, SE¼, NW¼, Sec. 17, T. 96 N., R. 18 W., Floyd County, Iowa.

Unit	Description	Thickness (feet)
	Devonian System	
	Shell Rock Formation	
	Nora Member	
9	Limestone biostrome, very pale yellowish-brown with zones of light-gray, dominantly composed of colonies of tabular stromatoporoids (*Actinostroma expansum*); galleries of stromatoporoids filled with calcspar; irregular small pockets and partings of very pale-orange, finely crystalline, slightly dolomitic limestone between stromatoporoid lamellae; slightly undulating upper and lower surfaces; massive	4.3
8	Shale, dark yellowish-orange, slightly dolomitic, silty; laminated	5.2
7	Limestone biostrome, very pale-orange, composed almost entirely of colonies of tabular stromatoporoids; irregular zones of pale-orange, finely crystalline, slightly dolomitic limestone; base moderately undulating; massive	4.1 - 4.6
	Rock Grove Member	
6	Dolomite, grayish-orange to dark yellowish-orange, medium crystalline, subhedral to anhedral, slightly calcareous; porous zones; molds of *Platyrachella ulsterensis*, *Schizophoria floydensis*, and crinoid ossicles abundant in upper part; weak cross-laminations in lower part; sharp lower contact; thick- to massive-bedded	4.3 - 4.7
5	Shale, dark yellowish-orange to grayish-orange, blocky, dolomitic; well indurated, but weathers to soft clay; poorly exposed	6.5
4	Limestone, grayish-orange, finely crystalline, moderately to very argillaceous, slightly dolomitic; weathers to soft blocks; massive	4.6
3	Limestone, grayish-orange in upper, more weathered two feet, very pale yellowish-brown below, very finely crystalline; ostracodes common, a few pelecypods; 0.1- to 0.3-foot layers separated by 0.03- to 0.15-foot partings of grayish-orange, slightly dolomitic shale; distinct upper and lower contacts	6.9
	Mason City Member	
2	Limestone, grayish-orange and very light olive-gray to very pale yellowish-brown, mottled, finely to medium crystalline; abundant corals, brachiopods and crinoid fragments; upper surface with rough iron-stained pits; two subequal units	3.1
1	Limestone, pale yellowish-brown, finely crystalline, moderately argillaceous; weathers to a chippy surface, slightly undercut; encrinital zones; exposed	5.0
	Covered interval to river level	4.0

Section 4


Thickness (feet)
Unit
Mbr.
Fm.
5.2
8
3.9
7
4.5
6
4.9
5
7.2
4
5.7
3
4.5
2
1
Upper stromatoporoid biostrome
Lower stromatoporoid biostrome
Quarry floor
Creek bed
Nora
Rock Grove
Mason City
SHELL ROCK

Section 3

TYPE SECTION OF THE NORA MEMBER

At the "Junction" in Nora Springs, NE¼, NW¼, Sec. 18, T. 96 N., R. 18 W., Floyd County, Iowa; section no longer exposed; description after Belanski 1927, p. 341-342.

Zone-zonule	Description	Thickness (feet)
	Devonian System	
	Shell Rock Stage	
	Nora Substage	
Second Actinostroma Zone		
Pseudotectus Zonule		
	Hard, white limestone in one massive bed, composed of crowded colonies of *Stromatopora*, *Actinostroma* and other stromatoporoids	4.8 - 5.2
Platyrachella Zone		
Unnamed Zonule		
	Soft, yellow-brown, magnesian shale, distinctly stratified	5.0
First Actinostroma Zone		
Expansum Zonule		
	Hard, white limestone in one massive bed, composed of laminar stromatoporoids, particularly *Actinostroma expansum*. A compound idiostromid common with occasional tabulate corals. The upper surface moderately undulating; lower highly so	4.5 - 5.0
	Rock Grove Substage	
Schizophoria Zone		
Ulsterensis Zonule		
	Firm, brownish, impure dolomite in several layers which increase in thickness upward. Upper portion contains abundant casts of *Platyrachella ulsterensis*, *Schizophoria floydensis* and other fossils. Base covered by sod	5.0

Section 4

REFERENCE SECTION FOR NORA AND ROCK GROVE MEMBERS

Abandoned quarry, NE¼, NE¼, Sec. 17, T. 96 N., R. 18 W., Floyd County, Iowa.

Unit	Description	Thickness (feet)
	Devonian System	
	Shell Rock Formation	
	Nora Member	
8	Limestone biostrome, pale yellowish-brown, composed of colonies of stromatoporoids (*Actinostroma expansum*); colonial growth often interrupted by lenses of grayish-orange, medium to finely crystalline, slightly argillaceous, dolomitic limestone; stylolites common; a few *Atrypa* and small horn corals; massive, slumped into underlying bed	5.2
7	Shale, dark yellowish-orange and very light olive-gray, dolomitic; thin lenses of dark yellowish-orange to grayish-orange, soft, argillaceous dolomite; a few molds of *Platyrachella ulsterensis*	3.9
6	Limestone biostrome, very pale-orange to pale yellowish-brown; composed of colonies of tabular stromatoporoids (*Actinostroma expansum*); moderately undulatory base; massive	4.5
	Rock Grove Member	
5	Dolomite, yellowish-gray with iron-stained zones ranging from dark yellowish-orange to dark reddish-brown; finely to medium crystalline, subhedral, slightly calcareous, porous; internal and external molds of *Platyrachella ulsterensis* and *Schizophoria floydensis* (the more weathered surfaces show cavities resulting from disintegration of internal molds); weak to prominent cross-laminae in lower part marked by differential iron-staining; undercut below; thick- to massive-bedded	4.9
4	Dolomite, light olive-gray to dark yellowish-orange, medium crystalline, calcareous, very argillaceous; intercalated with light olive-gray to dark yellowish-orange blocky, dolomitic shale; thin-bedded	7.2
3	Limestone, very pale yellowish-orange to light olive-gray, finely crystalline, very argillaceous, moderately dolomitic; weathers to a rough, pitted surface; massive	5.7
2	Limestone, very pale yellowish-brown to light olive-gray, very finely crystalline to sublithographic; ostracodes common, a few pelecypods and fish plates; 0.1- to 0.3-foot layers separated by olive-gray shale partings	4.5
	Mason City Member	
1	Limestone, pale yellowish-brown, finely crystalline, slightly argillaceous; *Strophеodonta* sp., *Pachyphyllum* sp., and crinoid ossicles abundant; shallow, iron-stained pits on upper surface; forms floor of creek.	

Section 5

COMPOSITE SECTION

Abandoned quarry, east bank of Flood Creek, north of railroad trestle, and natural exposure south of the trestle, NE¼, SW¼, SE¼, Sec. 13, T. 96 N., R. 18 W., Floyd County, Iowa.

Unit	Description	Thickness (feet)
	Devonian System	
	Shell Rock Formation	
	Nora Member	
5	Limestone biostrome, very pale-orange to pale yellowish-brown, composed dominantly of colonies of tabular stromatoporoids and *Prismatophyllum* sp. with a few brachiopod fragments; contains zones of grayish-orange, argillaceous, dolomitic limestone; one resistant, massive ledge, but slumped into underlying bed	3.7
	Rock Grove Member	
4	Dolomite, grayish-orange to dark yellowish-orange, finely to very finely crystalline, calcareous, argillaceous, shaly zones; incomplete molds of *Platyrachella ulsterensis* and *Schizophoria floydensis*	0.9
3	Shale, yellowish-orange to grayish-orange, slightly dolomitic, soft	4.9
2	Limestone, very light olive-gray to grayish-orange, finely to very finely crystalline, argillaceous, shaly zones; very fossiliferous in upper part including valves of *Schizophoria*, *Atrypa*, and *Stropheodonta*, small gastropods, crinoid columnals, and a few small subspherical stromatoporoids; weathers to a rough, knobby surface; massive	5.8
1	Limestone, very pale yellowish-brown, weathers to light olive-gray and bluish-gray, very finely crystalline, subconchoidal fracture; occurs in 0.1-foot to 0.3-foot layers separated by grayish-orange shale partings. This bed is poorly exposed in the floor of the quarry; it can be observed south of the railroad trestle; exposed to creek	2.5

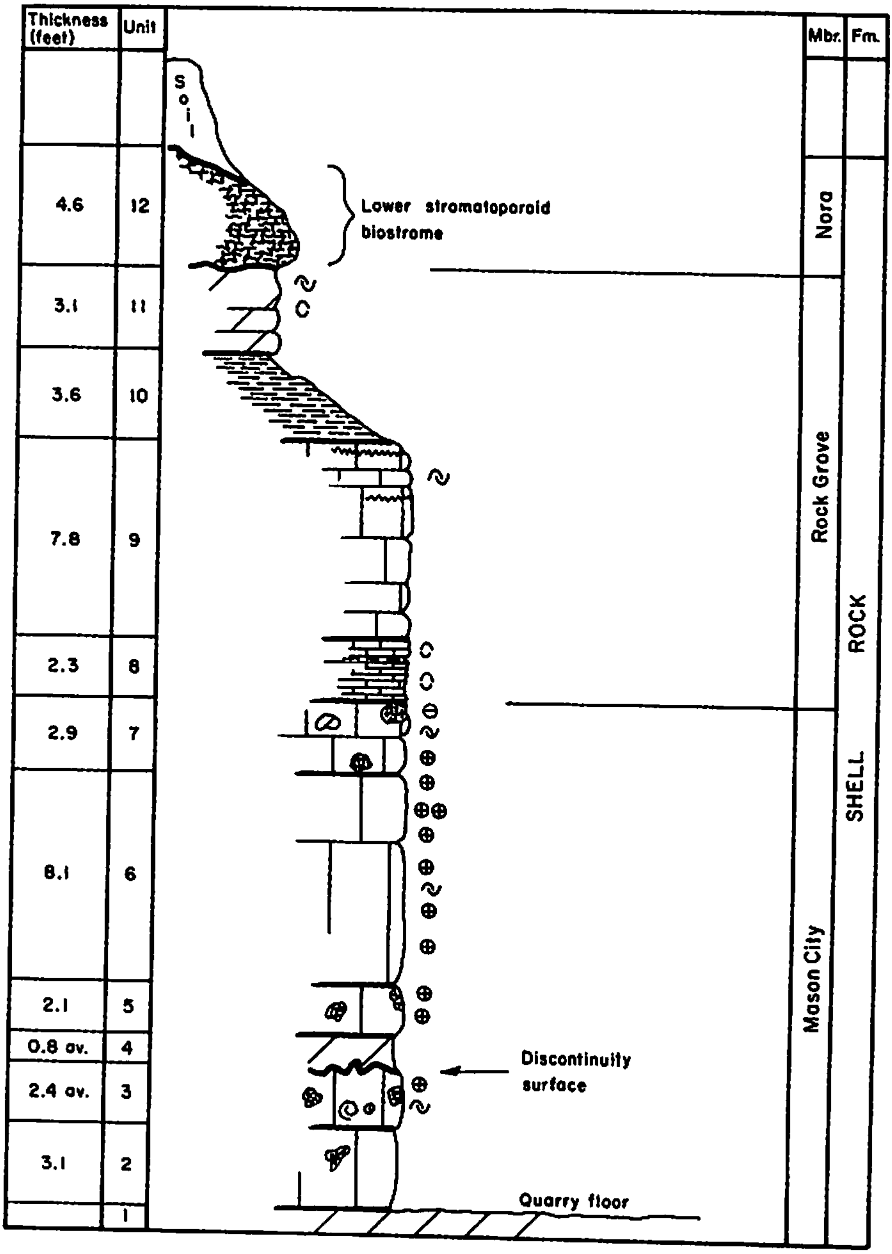
Section 6

ROADSIDE EXPOSURE

Measured in east bank of road ditch, NW¼, SW¼, SW¼., Sec. 16, T. 96 N., R. 18 W., Floyd County, Iowa.

Unit	Description	Thickness (feet)
	Cretaceous System	
	Undifferentiated	
1	Sandstone, light reddish-brown to pale yellowish-orange, very coarse to very fine sand-sized, major grade ½ to ¼mm; composed of subrounded to curvilinear and rounded, weakly polished quartz and chert grains; calcareous cement; iron-stained; scattered fine to medium sand-sized hematite grains; occurs in 0.1-foot to 0.3-foot broken layers; moderately to very friable; exposed to bottom of ditch	3.2

Section 7


Thickness (feet)
Unit
Mbr.
Fm.
Soil
4.6
12
3.1
11
3.6
10
7.8
9
2.3
8
2.9
7
8.1
6
2.1
5
0.8 av.
4
2.4 av.
3
3.1
2
1
Lower stromatoporoid biostrome
Discontinuity surface
Quarry floor
Nora
Rock Grove
Mason City
SHELL ROCK

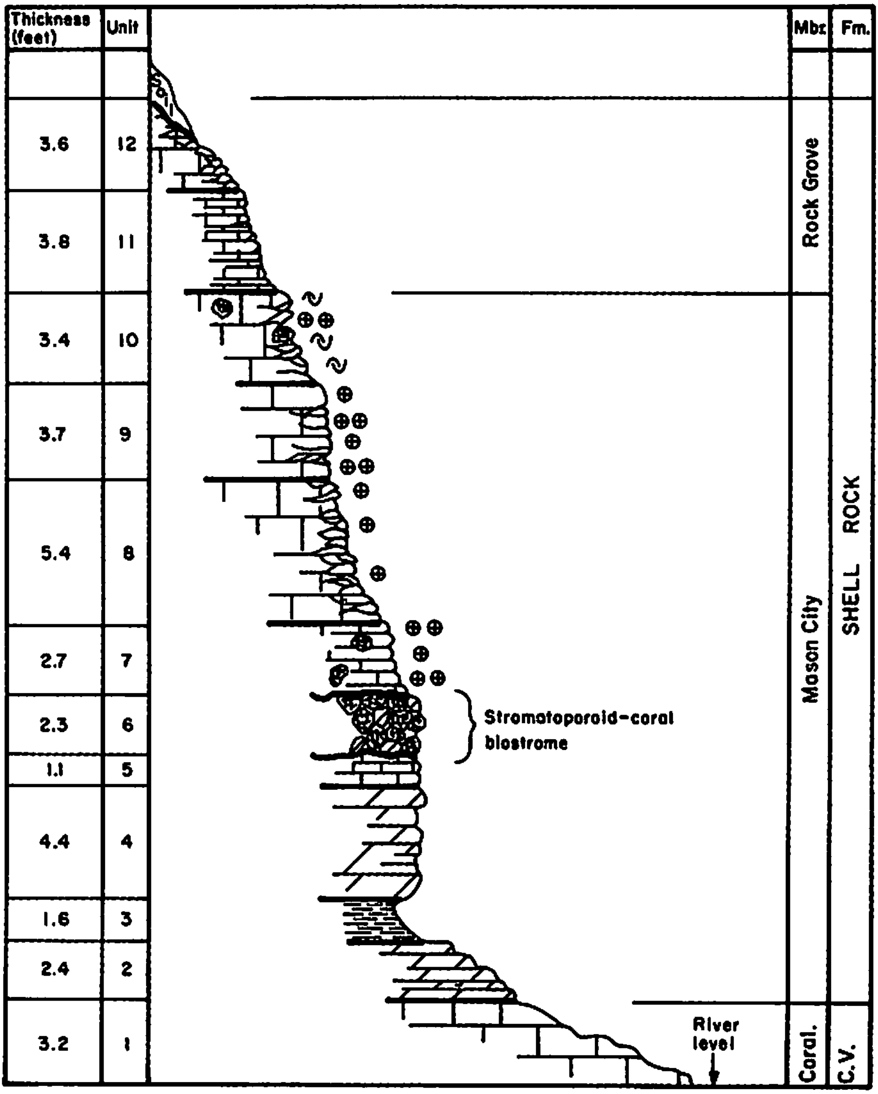
Section 7

WILLIAMS QUARRY

Located in E½, NW¼, SW¼, Sec. 28, T. 96 N., R. 18 W., Floyd County, Iowa; measured along east face.

Unit	Description	Thickness (feet)
	Devonian System	
	Shell Rock Formation	
	Nora Member	
12	Limestone biostrome, very pale yellowish-brown, composed almost entirely of colonies of tabular stromatoporoids (*Actinostroma expansum*); zones of dark yellowish-orange dolomitic limestone between some stromatoporoid lamellae; massive	4.6
	Rock Grove Member	
11	Dolomite, dark yellowish-orange to pale yellowish-brown, finely crystalline; a few molds of *Schizophoria floydensis* and *Platyrachella ulsterensis;* iron-stained; friable; weathers to dolomite sand; thick-bedded	3.1
10	Shale, dark yellowish-orange, laminated, slightly dolomitic, soft	3.6
9	Limestone, moderate yellowish-orange to light olive-gray, finely crystalline, slightly dolomitic, argillaceous; weathers to a nodular surface; a few micro-stylolites; massive-bedded	7.8
8	Limestone, light olive-gray, very finely crystalline, subconchoidal fracture; 0.1- to 0.3-foot continuous layers separated by grayish-orange shale partings; ostracodes common, pelecypods present, fish plates rare	2.3
	Mason City Member	
7	Limestone, light olive-gray and medium light-gray, weakly mottled, finely crystalline, argillaceous zones; scattered crinoid fragments, encrinital lenses, *Strophcodonta* sp., *Camarophoria paupera, Spirifer cardinalis*, a few *Pachyphyllum* sp., subspherical stromatoporoids; upper surface with shallow iron-stained pits; massive-bedded	2.9
6	Limestone, pale yellowish-brown, mottled with grayish-orange, very finely crystalline, argillaceous; scattered crinoid fragments, an encrinital zone 1.3-feet below top; massive-bedded	8.1
5	Limestone, yellowish-brown, and olive-gray, mottled, finely crystalline; scattered crinoid fragments and a few small subspherical stromatoporoids; top of bed marked by a 0.3-foot interval of mottled light olive-gray and dark-gray, finely crystalline, argillaceous, pyritic, algal(?) limestone with small pockets of crinoidal debris; massive-bedded	2.1
4	Dolomite, light olive-gray, weathering to grayish-orange, medium crystalline, euhedral to subhedral, calcareous, argillaceous, shaly zones; planar upper surface, very irregular lower surface filling in and around knobby limestone of underlying bed	0.2 - 1.9
3	Limestone, light brownish-gray, weathering to pale yellowish-brown, very finely crystalline; irregular knobby upper surface an intraformational discontinuity surface with 0.2- to 0.7-foot relief; fauna of attached biocoenose includes *Adocetocystis williamsi, Strobilocystites calvini, Agelacrinites hanoveri, Aulopora* sp., *Hernodia* sp., and *Spirorbis;* sponge(?) borings in limestone are filled with dolomite of bed 4; lower part of bed contains brachiopods, crinoid ossicles, subspherical stromatoporoids and *Amphipora*, corals and gastropods; relief on top surface decreases to the south as the overlying bed increases in thickness; maximum measured thickness	2.4
2	Limestone, pale yellowish-brown to light olive-gray, sublithographic to lithographic; a few scattered stromatoporoid fragments; intraclasts in lower part; "floating" dolomite crystals common; argillaceous at base; thick-bedded	3.1
1	Quarry floor—dolomite, light olive-gray, medium-grained, sub-saccharoidal, slightly calcareous, argillaceous zones.	

Section 8


Thickness (feet)
Unit
Mbr.
Fm.
3.6
12
3.8
11
3.4
10
3.7
9
5.4
8
2.7
7
2.3
6
1.1
5
4.4
4
1.6
3
2.4
2
3.2
1
Soil
Stromatoporoid-coral biostrome
River level
Rock Grove
Mason City
Coral.
SHELL ROCK
C.V.

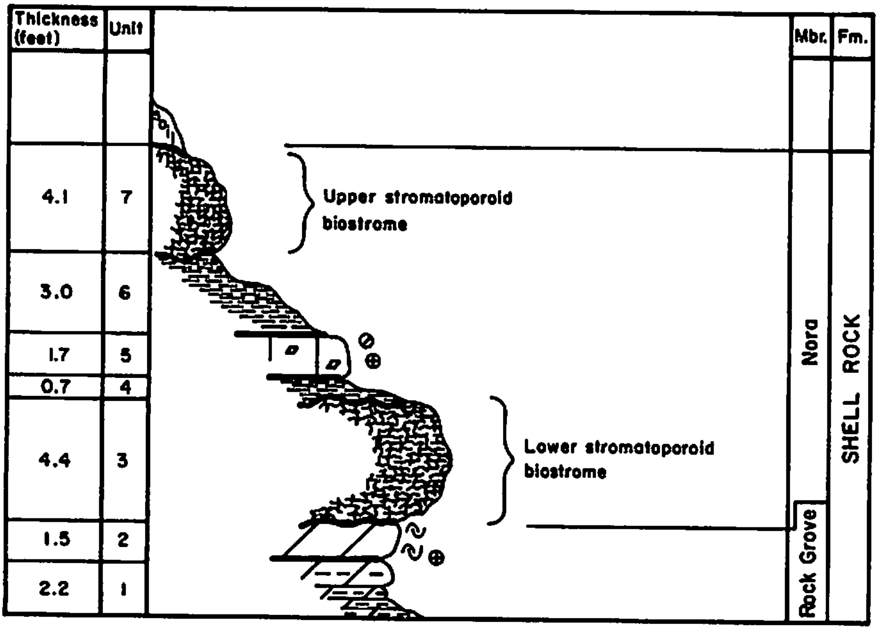
Section 8

ABANDONED MILL SITE (BAUMGARDNER MILL)

Left bank of Shell Rock River, west line of SE¼, SW¼, SW¼, Sec. 28, T. 96 N., R. 18 W., Floyd County, Iowa.

Unit	Description	Thickness (feet)
	Devonian System	
	Shell Rock Formation	
	Rock Grove Member	
12	Limestone, yellowish-orange, finely crystalline, dolomitic, very argillaceous; broken beds, weathering to a rough, pitted surface; thick-bedded	3.6
11	Limestone, light olive-gray to very pale yellowish-brown, very finely crystalline, sub-conchoidal fracture; 0.1- to 0.3-foot continuous layers separated by grayish-orange shale partings; bottom 0.1 foot laminated in ⅛-inch layers; ostracodes common, pelecypods rare	3.8
	Mason City Member	
10	Limestone, very pale yellowish-brown, finely to very finely crystalline, with argillaceous zones; moderately fossiliferous, including *Atrypa* sp., *Camarophoria paupera*, *Stropheodonta* sp., crinoid fragments, encrinital zones and a few small subspherical stromatoporoids; upper surface with shallow iron-stained pits; massive-bedded	3.4
9	Limestone, very pale yellowish-brown to grayish-orange, finely to very finely crystalline, slightly argillaceous; scattered crinoid fragments, encrinital zones, brachiopod fragments; dolomitic in lower part; thin- to thick-bedded	3.7
8	Limestone, pale yellowish-brown, very finely crystalline, slightly argillaceous; a few scattered crinoid fragments; massive-bedded	5.4
7	Limestone, very pale yellowish-brown, finely crystalline, slightly dolomitic; mottled with grayish-orange, very finely crystalline, slightly argillaceous, dolomitic limestone; encrinital zones and a few small subspherical stromatoporoids; thin-bedded	2.7
6	Limestone biostrome, composed of subspherical stromatoporoids (averaging four to six inches in diameter) and a few colonial corals in a matrix of medium-gray, finely crystalline, argillaceous limestone	2.3
5	Limestone, pale yellowish-brown, sublithographic to lithographic; "floating" dolomite crystals; intraclasts in lower 0.3-foot; thin-bedded	1.1
4	Dolomite, grayish-orange, medium crystalline, slightly calcareous; scattered small calcite-lined vugs near middle; very argillaceous in lower part; thin- to thick-bedded	4.4
3	Shale, yellowish-gray to yellowish-orange, dolomitic; weakly laminated; soft ..	1.6
2	Dolomite, very pale yellowish-brown to dark yellowish-brown, medium crystalline, subhedral, calcareous; scolecodont fragments in middle; thin-bedded; terraced toward river	2.4
	Cedar Valley Formation	
	Coralville Member	
1	Limestone, pale yellowish-brown with some dusky-red mottling, lithographic; scattered calcspar; a few calcisphere structures averaging ⅛mm in diameter; mottled with pale-orange, argillaceous dolomite in top one foot which weathers readily, yielding a rough, pitted surface; thick-bedded; terraced to water	3.2

Section 9



Section 9

ROCKFORD SECTION

Left bank of Winnebago River, west side of bridge, NE¼, SW¼, NW¼, Sec. 15, T. 95 N., R. 18 W., Floyd County, Iowa.

Unit	Description	Thickness (feet)
	Devonian System	
	Shell Rock Formation	
	Nora Member	
7	Limestone biostrome, light yellowish-gray to very pale-orange, composed almost entirely of colonies of tabular stromatoporoids (*Actinostroma expansum*); lenses of pale yellowish-brown, medium grained, slightly dolomitic limestone; small *Atrypa*; massive-bedded	4.1
6	Shale, grayish-orange to dark yellowish-orange, dolomitic, soft; weakly laminated	2.6 - 3.4
5	Limestone, pale yellowish-brown to grayish-orange, very finely to finely crystalline; zones with "floating" dolomite crystals; *Aulopora* common, few scattered crinoid fragments; fucoidal markings on bedding planes; thin-bedded	1.7
4	Shale, grayish-orange to dark yellowish-orange, slightly dolomitic; firm	0.4 - 1.0
3	Limestone biostrome, very pale-orange to very pale yellowish-brown, composed almost entirely of colonies of tabular stromatoporoids (*Actinostroma expansum*); lenses of grayish-orange, finely crystalline dolomitic limestone; even upper contact, undulating lower contact; massive-bedded	4.1 - 4.8
	Rock Grove Member	
2	Dolomite, dark yellowish-orange and pale yellowish-brown, medium crystalline; zones with abundant molds of crinoid columnals, numerous molds of *Platyrachella ballardi* and *Schizophoria rockfordensis*; *Atrypa* sp. common; very few *Strobilocystites*(?) molds; one bed	1.5
1	Dolomite, yellowish-orange to very pale yellowish-brown, finely to medium crystalline; slightly argillaceous, weakly calcareous; porous; broken beds	2.2
	Slump-covered to river level.	

Section 10

ROADCUT EXPOSURE

Beginning 150 feet west of a tributary to Flood Creek and including the west (right) bank of the tributary; SWcor., SE¼, Sec. 25, T. 95 N., R. 17 W., Floyd County, Iowa.

Unit	Description	Thickness (feet)
	Devonian System	
	Shell Rock Formation	
	Rock Grove Member	
4	Limestone, very pale yellowish-brown, very finely crystalline to sublithographic; ostracodes common, a few crinoid fragments; 0.1- to 0.3-foot layers with a few pale yellowish-brown shale partings	0.8
	Mason City Member	
3	Limestone, grayish-orange-pink to very pale yellowish-brown, finely crystalline; brachiopod and crinoid fragments, small gastropods, small subspherical stromatoporoids, corals, and bryozoans; charophyte oogonia rare; top surface with shallow iron-stained pits	0.6
2	Limestone, pale yellowish-brown to light grayish-orange, very finely crystalline; scattered crinoid fragments and encrinital lenses, ostracodes common, few brachiopods and small gastropods; fucoidal markings on bedding planes; thin-bedded; lower part partially talus-covered	4.3
	Cedar Valley Formation	
	Coralville Member	
1	Limestone, very pale-orange to very pale yellowish-brown, lithographic; abundant calcisphere structures; scattered calcspar; weakly mottled with patches of dark yellowish-orange, finely crystalline, slightly dolomitic, slightly argillaceous limestone in upper three feet; lower four feet packed with subspherical stromatoporoids; thick- to massive-bedded; poorly exposed to creek bed	13.5

Section 11

ABANDONED QUARRY

South bank of Ackley Creek, SW¼, SW¼, NW¼, Sec. 20, T. 94 N., R. 17 W., Floyd County, Iowa.

Unit	Description	Thickness (feet)
	Devonian System	
	Shell Rock Formation	
	Mason City Member	
3	Limestone, yellowish-orange to pale yellowish-brown, very finely crystalline; slightly dolomitic zones; fossils include scattered crinoid fragments, ostracodes, *Dentalium*, and a few brachiopod fragments; thin- to thick-bedded	4.4
2	Shale, very pale yellowish-orange, very calcareous, soft; fossiliferous, including abundant crinoid fragments, brachiopods (*Atrypa reticularis*, *Schizophoria* sp.) and numerous small gastropods; distinct upper contact, uneven lower contact	0.4 - 1.5
	Cedar Valley Formation	
	Coralville Member	
1	Limestone, very pale-orange to light grayish-orange, lithographic to sublithographic; scattered calcisphere structures averaging ⅛mm in diameter; gastropods and small subspherical stromatoporoids common; thick- to massive-bedded; to quarry floor	13.8

Section 12

QUARRY SECTION

South bank of Dry Run Creek, NE¼, SE¼, SW¼, Sec. 7, T. 94 N., R. 15 W., Floyd County, Iowa.

Unit	Description	Thickness (feet)
	Devonian System	
	Shell Rock Formation	
	Mason City Member	
5	Limestone, pale yellowish-brown to light grayish-orange, very finely crystalline, mottled with irregular patches of yellowish-orange, finely crystalline, argillaceous, slightly dolomitic limestone; crinoid fragments scattered throughout, ostracodes common; thin-bedded, broken	3.1
4	Shale, dark yellowish-orange, blocky, very calcareous; contains scattered nodular, yellowish-orange to pale yellowish-brown, finely crystalline limestone; lower 0.4 foot more indurated and uniform; slightly undulating base	2.4
	Cedar Valley Formation	
	Coralville Member	
3	Limestone, very pale yellowish-brown to pale-orange, lithographic to sublithographic, pelletiferous zones; scattered calcspar; numerous ostracodes; abundant calcisphere structures averaging ⅛mm in diameter; irregular upper and lower contact; massive	2.3
2	Limestone biostrome, composed of pale yellowish-brown subspherical stromatoporoids in a matrix of grayish-orange to very pale-orange, very finely crystalline, argillaceous limestone; massive; variable thickness; maximum	3.8
1	Limestone, pale-orange, lithographic, scattered calcspar; numerous ostracodes; abundant calcisphere structures averaging ⅛mm in diameter; numerous stylolite seams; massive- to thin-bedded with clay partings between beds	5.1

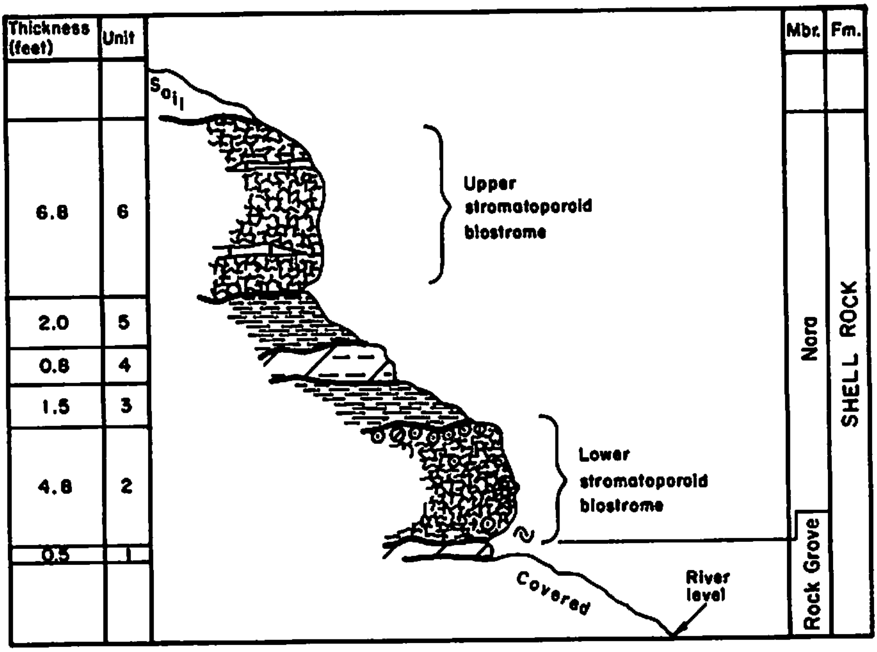
Section 13

ROADSIDE AND CREEK BANK EXPOSURE

West side of Iowa Highway No. 14, north bank of Coldwater Creek, NE¼, NE¼, Sec. 14, T. 93 N., 17 W., Butler County, Iowa.

Unit	Description	Thickness (feet)
	Devonian System	
	Shell Rock Formation	
	Rock Grove Member	
3	Limestone, grayish-orange, very finely crystalline to sublithographic, in 0.1- to 0.2-foot layers; ostracodes present; lower contact poorly exposed	2.9
	Mason City Member	
2	Limestone, pale yellowish-brown, very finely crystalline, mottled with irregular patches of grayish-orange, very finely crystalline, slightly dolomitic limestone; abundant crinoid fragments, *Atrypa* sp. common, a few gastropods and rugose corals; lower contact poorly exposed	4.4
	Cedar Valley Formation	
	Coralville Member	
1	Limestone, very pale yellowish-brown to pale yellowish-orange, lithographic, mottled with irregular patches of dark yellowish-orange, soft, argillaceous, dolomitic limestone containing scattered grains of coarse sand-sized, rounded, polished quartz; a few calcisphere structures averaging ⅛mm in diameter; abundant subspherical stromatoporoids up to six inches in diameter, and *Amphipora*; weathers with fossils in relief and exhibits a pitted surface where the softer, dolomitic limestone has been removed; massive; exposed	2.3

Section 14



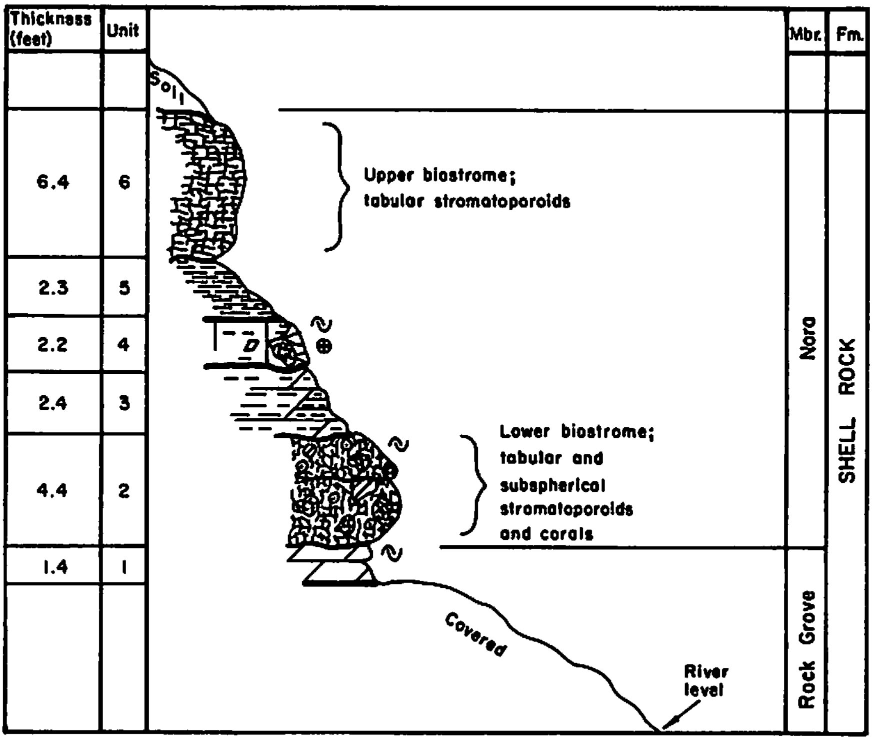
Section 14

SHELL ROCK RIVER SECTION

East (left) bank of river, SE¼, NE¼, NE¼, Sec. 12, T. 96 N., R. 19 W., Cerro Gordo County, Iowa.

Unit	Description	Thickness (feet)
	Devonian System	
	Shell Rock Formation	
	Nora Member	
6	Limestone biostrome, pale-orange to pale yellowish-brown, composed almost entirely of colonies of tabular stromatoporoids (*Actinostroma expansum*); lenses of dark yellowish-orange, soft, argillaceous, dolomitic limestone; one resistant, massive bed	6.8
5	Shale, grayish-orange, soft, calcareous to slightly dolomitic, blocky to weakly laminated; a few poorly preserved molds of *Platyrachella* sp.; variable thickness	1.9 - 2.2
4	Dolomite, moderate yellowish-brown, medium crystalline, subhedral to anhedral, very calcareous, argillaceous; small, irregular vugs lined with scalenohedral calcite; this bed is only 0.5-foot thick at southern end of exposure; one bed; maximum	1.4
3	Shale, as in bed 5, gradational with bed 4 locally; moderately undulating base, variable thickness	1.4 - 1.7
2	Limestone biostrome, very pale yellowish-brown, dominantly composed of colonies of tabular stromatoporoids; the top 0.3 to 0.8 foot is packed with *Amphipora*, fragmented tabular stromatoporoids and scattered corals; a few *Amphipora* scattered throughout the lower part, subspherical stromatoporoids rare; undulating base; one massive bed	4.8
	Rock Grove Member	
1	Dolomite, moderate yellowish-brown, medium crystalline, subhedral to anhedral, very calcareous, porous; very fossiliferous, including molds of *Platyrachella ulsterensis*, *Atrypa* sp., and abundant crinoid columnals; exposed	0.5
	Covered to water	3.1

Section 15


Thickness (feet)
Unit
Mbr.
Fm.
6.4
6
2.3
5
2.2
4
2.4
3
4.4
2
1.4
1
Soil
Upper biostrome; tabular stromatoporoids
Lower biostrome; tabular and subspherical stromatoporoids and corals
Covered
River level
Nora
Rock Grove
SHELL ROCK

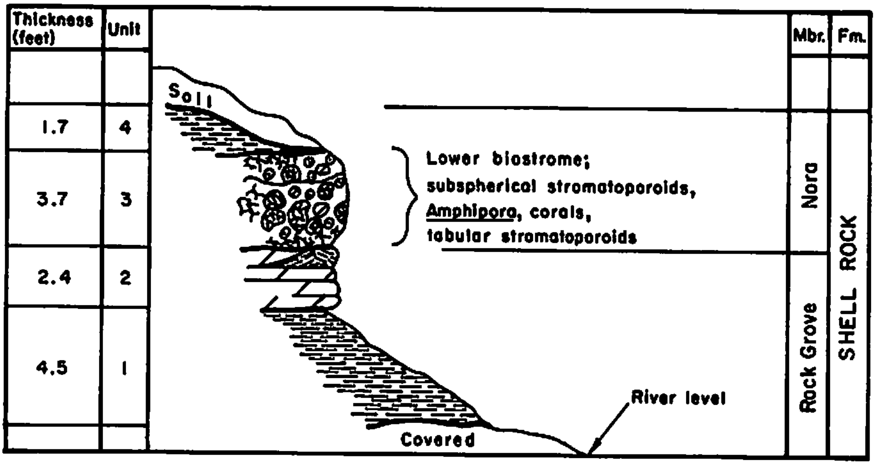
Section 15

SHELL ROCK RIVER SECTION

East (left) bank of river, Ctr. NW¼, SW¼, SE¼, Sec. 1, T. 96 N., R. 19 W., Cerro Gordo County, Iowa.

Unit	Description	Thickness (feet)
	Devonian System	
	Shell Rock Formation	
	Nora Member	
6	Limestone biostrome, very pale-orange, composed almost entirely of colonies of tabular stromatoporoids (*Actinostroma expansum*); irregular laminae of light-brown, finely crystalline, argillaceous, dolomitic limestone between stromatoporoid colonies; moderately undulating base; one resistant, massive bed	6.4
5	Shale, moderate yellowish-brown, dolomitic, weakly laminated; distinct upper and lower contact	2.3
4	Limestone, pale yellowish-brown, very finely to finely crystalline, argillaceous; "floating" medium crystalline dolomite crystals; disseminated carbonaceous(?) flecks; moderately fossiliferous, including crinoid columnals, brachiopod fragments, and a few small subspherical stromatoporoids; grades to moderate yellowish-brown and light olive-gray, medium crystalline, anhedral to subhedral, slightly calcareous dolomite in lower 0.8 foot; thin-bedded	2.2
3	Dolomite, light grayish-orange, finely crystalline, anhedral to subhedral, very argillaceous, slightly calcareous; grades to shale laterally; variable thickness; maximum	2.4
2	Limestone biostrome, very pale yellowish-brown to grayish-orange, composed of colonies of tabular stromatoporoids (dominant), subspherical stromatoporoids, and a few corals and *Amphipora*; upper 1.8 feet dolomitic; stromatoporoids are fragmented and *Cladopora* sp. abundant; one massive bed	4.4
	Rock Grove Member	
1	Dolomite, pale yellowish-brown, medium crystalline, subhedral to anhedral, very slightly calcareous; few molds of *Platyrachella ulsterensis* and crinoid columnals; weak cross-laminations brought out by differential weathering and iron-oxide staining; thick-bedded; exposed	1.4
	Covered to water	6.1

Section 16



Section 16

SHELL ROCK RIVER SECTION

West (right) bank of river, Ctr. NW¼, SE¼, NW¼, Sec. 1, T. 96 N., R. 19 W., Cerro Gordo County, Iowa.

Unit	Description	Thickness (feet)
	Devonian System	
	Shell Rock Formation	
	Nora Member	
4	Shale, yellowish-orange, soft, dolomitic; mixed with yellowish-orange, calcareous, argillaceous dolomite	1.7
3	Limestone biostrome, light grayish-orange to pale yellowish-brown, composed of subspherical stromatoporoids (dominantly 2"-6" in diameter, a few as large as 14" in diameter), *Amphipora*, corals, a few colonies of tabular stromatoporoids, and brachiopods (*Trigonotreta shellrockensis*); matrix is finely crystalline, slightly argillaceous, very dolomitic limestone; one massive, resistant bed	3.7
	Rock Grove Member	
2	Dolomite, yellowish-orange to moderate yellowish-brown, medium crystalline, slightly calcareous; very fine cross-laminations in upper part; thick-bedded	2.4
1	Shale, yellowish-orange to light olive-gray, soft, dolomitic; exposed	4.5
	Covered to water	1.1

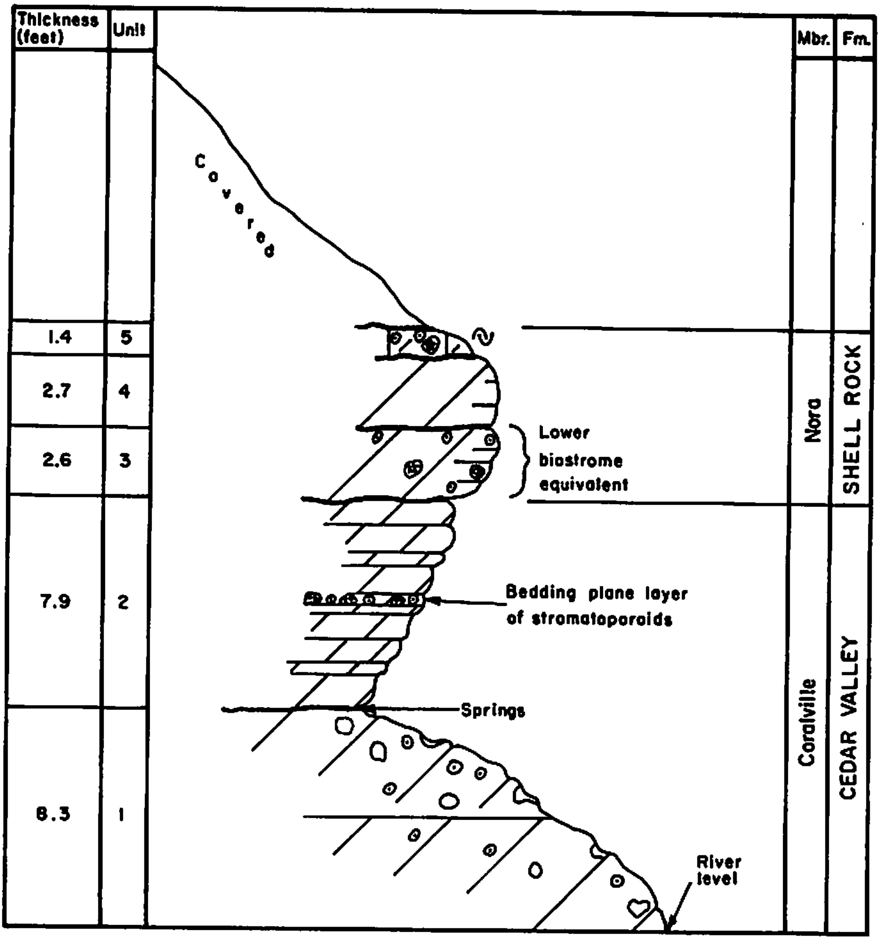
Section 17

RAVINE SECTION

Along both sides of ravine, NW¼, SW¼, NW¼, NE¼, Sec. 1, T. 96 N., R. 19 W., Cerro Gordo County, Iowa.

Unit	Description	Thickness (feet)
	Devonian System	
	Lime Creek Formation	
	Juniper Hill Member	
6	Shale, light bluish-gray, weathers to light grayish-orange; weakly laminated, slightly dolomitic; crushed spore carps abundant; exposed only at upper end of ravine	2.9
	Shell Rock Formation	
	Nora Member	
5	Limestone biostrome, very light olive-gray to very pale yellowish-brown, composed almost entirely of colonies of tabular stromatoporoids; irregular lenses of grayish-orange, very finely crystalline, slightly dolomitic limestone between stromatoporoid colonies; one resistant, massive bed	6.5
4	Shale, dark yellowish-orange, soft, slightly dolomitic	0.6
3	Limestone, pale yellowish-brown, finely crystalline, dolomitic; encrinital zones, *Platyrachella ballardi* common; abundant carbonaceous flecks; grades to dolomite in lower part; thick-bedded	3.3
2	Dolomite, light olive-gray, finely crystalline, very argillaceous, calcareous; fucoidal casts common; shaly zones; thick-bedded	2.9
1	Limestone biostrome, pale to dark yellowish-brown, composed of subspherical stromatoporoids in a matrix of dark yellowish-orange, finely crystalline, slightly argillaceous, dolomitic limestone; exposed	1.3

Section 18


Thickness (feet)
Unit
Mbr.
Fm.
Covered
1.4
5
2.7
4
2.6
3
7.9
2
8.3
1
Lower biostrome equivalent
Bedding plane layer of stromatoporoids
Springs
River level
Nora
Coralville
SHELL ROCK
CEDAR VALLEY

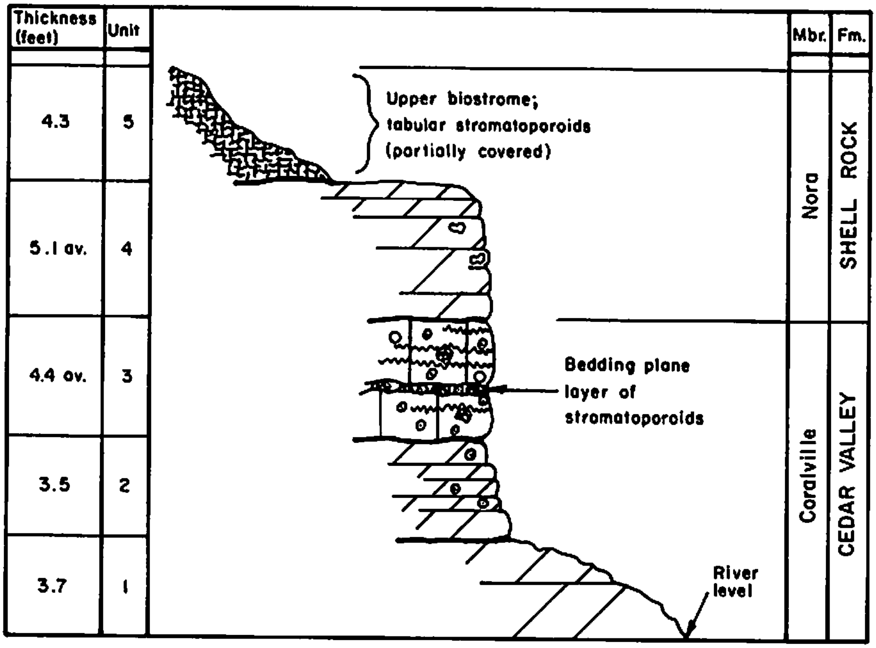
Section 18

KEIDLE'S BLUFF SECTION

East (left) bank of Shell Rock River, Ctr. of E½, SW¼, Sec. 26, T. 97 N., R. 19 W., Cerro Gordo County, Iowa; measured at north end of bluff.

Unit	Description	Thickness (feet)
	Devonian System	
	Shell Rock Formation	
	Nora Member	
5	Limestone, grayish-orange, finely crystalline, slightly dolomitic; fossils are fragmented and include *Amphipora*, brachiopods, and a few abraded subspherical stromatoporoids averaging four inches in diameter; the limestone is mottled with patches of pale yellowish-brown, medium crystalline, calcareous dolomite containing scattered, small calcite-lined vugs; upper surface sod-covered; one bed	1.4
4	Dolomite, pale to dark yellowish-brown, medium crystalline, subhedral to anhedral, slightly calcareous; variable porosity; dusky yellowish-brown carbonaceous partings in lower part; thick-bedded	2.7
3	Dolomite, dark yellowish-brown to grayish-orange, medium crystalline, slightly calcareous; porous zones; abundant slightly altered *Amphipora* in upper part, a few *Amphipora* and abundant small, subspherical stromatoporoids below; massive; lower surface moderately undulating	2.6
	Cedar Valley Formation	
	Coralville Member	
2	Dolomite, pale yellowish-brown, medium crystalline, subhedral, slightly calcareous; very tough; thick- to massive-bedded; bedding plane with altered two-inch diameter subspherical stromatoporoids four feet below top; beds successively undercut; springs are present at the base	7.9
1	Dolomite, dark yellowish-brown, medium crystalline, subhedral to anhedral, calcareous; finely disseminated carbonaceous flecks which yield the dark color; abundant calcite-filled vugs and calcite "stalks", probably the remains of subspherical stromatoporoids and corals, and *Amphipora* respectively; weathers to a rough, knobby surface sloping out toward river; massive; to water	8.3

Section 19


Thickness (feet)
Unit
Mbr.
Fm.
4.3
5
5.1 av.
4
4.4 av.
3
3.5
2
3.7
1
Upper biostrome; tabular stromatoporoids (partially covered)
Bedding plane layer of stromatoporoids
River level
Nora
Coralville
SHELL ROCK
CEDAR VALLEY

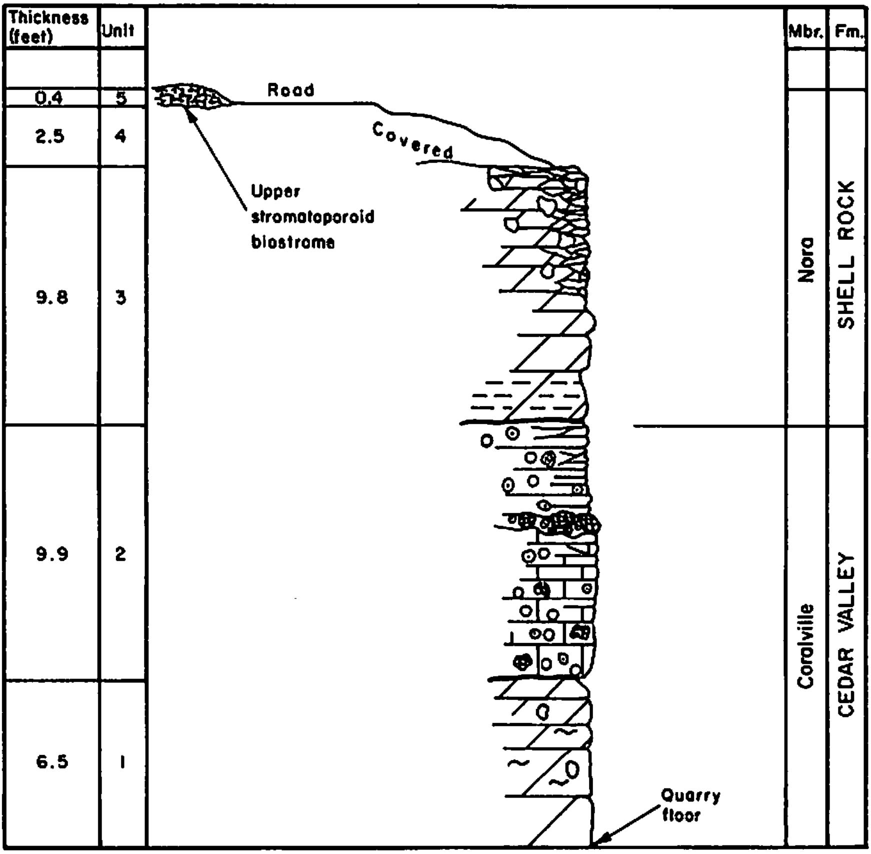
Section 19

BAKER'S BLUFF SECTION

Along north line of SE¼, SE¼, Sec. 27, T. 97 N., R. 19 W., Cerro Gordo County, Iowa.

Unit	Description	Thickness (feet)
	Devonian System	
	Shell Rock Formation	
	Nora Member	
5	Limestone biostrome, very pale yellowish-brown to pale-red, composed almost entirely of colonies of tabular stromatoporoids; irregular lenses of grayish-orange, finely crystalline, argillaceous, dolomitic limestone between stromatoporoid colonies; upper and lower surfaces poorly exposed (exposed near head of spring-fed drainage about 40 feet south of bluff); massive	4.3
4	Dolomite, pale yellowish-brown to grayish-orange, medium crystalline, subhedral to anhedral, calcareous; small, calcite-lined and filled vugs common in middle; trace of stromatoporoid fragments; thick-bedded; variable thickness	4.9 - 5.3
	Cedar Valley Formation	
	Coralville Member	
3	Limestone, grayish-orange-pink, sublithographic; scattered subspherical stromatoporoids from two to five inches in diameter, numerous *Amphipora;* calcispheres averaging ⅛mm in diameter common, more abundant in lower part; numerous stylolite seams; bedding plane concentration of small subspherical stromatoporoids and *Amphipora* 2.8 feet below top; unit grades to dolomite laterally; massive- to thick-bedded; variable thickness	4.1 - 4.8
2	Dolomite, pale yellowish-brown, medium crystalline, subhedral, slightly to very calcareous; scattered calcite "stalks" are altered *Amphipora;* thick-bedded	3.5
1	Dolomite, dark yellowish-brown to dusky yellowish-brown, medium crystalline, subhedral, calcareous; calcite "stalks" in upper part (altered *Amphipora*), calcite vugs up to six inches across in lower part (altered stromatoporoids or corals); disseminated carbonaceous flecks throughout; massive; weathers to a rough, knobby surface; to water	3.7

Section 20


Thickness (feet)
Unit
Mbr.
Fm.
0.4
5
2.5
4
9.8
3
9.9
2
6.5
1
Road
Covered
Upper stromatoporoid biostrome
Quarry floor
Nora
SHELL ROCK
Coralville
CEDAR VALLEY

Section 20

QUARRY SECTION

Half a mile northwest of Rock Falls; NE¼, SE¼, SE¼, SW¼, Sec. 16, T. 97 N., R. 19 W., Cerro Gordo County, Iowa; composite section of west face.

Unit	Description	Thickness (feet)
	Devonian System	
	Shell Rock Formation	
	Nora Member	
4	Limestone biostrome, pale-orange, composed of colonies of tabular stromatoporoids; poorly exposed, observed only on west side of road west of quarry; exposed	0.4
	Covered interval; road bed, soil	2.5
3	Dolomite, pale yellowish-brown to grayish-orange, medium crystalline, subhedral to anhedral, calcareous; abundant calcite-lined and filled vugs (calcitized stromatoporoids or corals?); highly fractured and broken in upper one-half; very argillaceous; thick- to massive-bedded; fills shallow depression in Cedar Valley; present only in northwest corner of quarry; maximum	9.8
	Cedar Valley Formation	
	Coralville Member	
2	Limestone, very pale yellowish-brown to grayish-orange-pink, sublithographic, variably pelletiferous; abundant *Amphipora* and scattered small subspherical stromatoporoids; a conspicuous zone from 0.6 to 1.0 foot in thickness and 3.5 feet below top is crowded with *Amphipora* and subspherical stromatoporoids; calcisphere structures averaging ⅛mm in diameter occur throughout this unit but are more abundant in the lower part; upper part grades to dolomite laterally; massive-bedded; variable thickness	9.5-10.6
1	Dolomite, pale to dark yellowish-brown, medium crystalline, subhedral to anhedral, slightly calcareous; a few calcite-filled vugs up to three inches in diameter; zones of "vermicular" openings which are remains of calcitized and dissolved *Amphipora;* three to five stylolite seams; massive; to quarry floor	6.5

Section 21

QUARRY NEAR ABANDONED MILL SITE (FOSTER'S MILL)

West bank of Shell Rock River; NW¼, SW¼, NW¼, Sec. 29, T. 98 N., R. 19 W., Worth County, Iowa.

Unit	Description	Thickness (feet)
	Devonian System	
	Shell Rock Formation	
	Nora Member	
4	Dolomite, pale orange to pale-yellowish-brown, medium crystalline, calcareous; abundant calcite-lined and filled vugs up to five inches in diameter (altered subspherical stromatoporoids and corals); "vermicular" openings common (calcitized and dissolved *Amphipora*); upper part very iron-stained; massive, broken beds; variable thickness	6.0-12.0
3	Dolomite breccia, composed of light olive-gray, medium crystalline, subhedral, calcareous, angular dolomite fragments up to one inch in length; fragments are in a matrix of medium-gray to light olive-gray, medium crystalline, calcareous, slightly argillaceous dolomite; top of unit has a discontinuous zone of medium light-gray, medium crystalline, very argillaceous, finely laminated dolomite showing contorted bedding	0.0 - 1.7
	Cedar Valley Formation	
	Coralville Member	
2	Limestone, pale-orange, with zones of yellowish-gray to light-gray and grayish-orange-pink mottling, sublithographic to lithographic, variably pelletiferous; "floating" dolomite(?) crystals, more abundant in lower part; abundant calcisphere structures averaging ⅛mm in diameter; a few *Amphipora;* highly irregular upper surface, distinct lower contact; massive-bedded; not everywhere present	0.0 - 7.5
1	Dolomite, very pale yellowish-brown, medium crystalline, slightly calcareous, subhedral; moderate porosity; some "vermicular" porosity, the walls lined with coarsely crystalline dolomite; massive; to floor of quarry	5.7

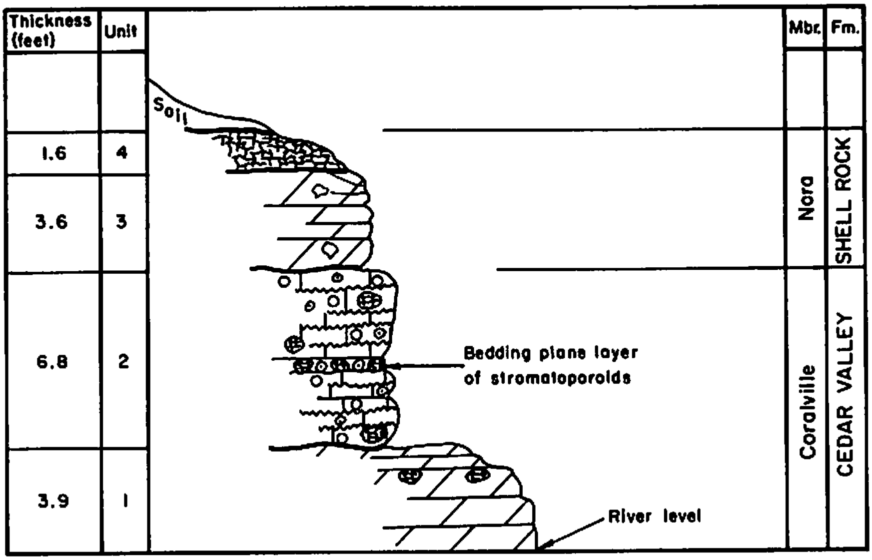
Section 22

McEACHRAN QUARRY

One-half mile south of Portland, south (right) bank of Winnebago River, SW¼, SW¼, NW¼, Sec. 20, T. 96 N., R. 19 W., Cerro Gordo County, Iowa; see figure 17.

Unit	Description	Thickness (feet)
	Devonian System	
	Shell Rock Formation	
	Nora Member	
4	Limestone biostrome, very pale-orange to grayish-orange, composed almost entirely of colonies of tabular stromatoporoids; lower part exhibits interrupted colonial growth of stromatoporoids as evidenced by alternating layers of stromatoporoids and limestone; small *Atrypa* and rugose corals common in upper part; lower surface very irregular with up to 3 feet of relief and conforming to depressions in underlying unit; massive	4.2 - 7.5
3	Dolomite, pale to dusky yellowish-brown and olive-black, medium crystalline, subhedral, very tough; abundant calcite-filled vugs from 1 inch to 1 foot across (calcitized subspherical stromatoporoids); zones with concentrations of carbonaceous flecks, especially near base; irregular upper and lower surfaces conforming to surface of underlying unit; in contact with unit 1 where unit 2 is absent; massive	3.8 - 6.2
	Cedar Valley Formation	
	Coralville Member	
2	Limestone, medium-gray to light olive-gray and very pale yellowish-brown, sublithographic, variably pelletiferous; contains many calcisphere structures averaging ⅛mm in diameter; subspherical stromatoporoids and *Amphipora* scattered throughout; distinct bedding plane concentration of smaller subspherical stromatoporoids and *Amphipora* approximately 2 feet below top; numerous stylolite seams; massive; unit not everywhere present along the east face	0.0 - 8.5
1	Dolomite, very pale to dusky yellowish-brown, medium crystalline, subhedral to euhedral; very tough; scattered subspherical stromatoporoids (calcitized), and zones of "vermicular" porosity (result of calcitization and solution of *Amphipora*); massive- to thick-bedded; top of this unit forms floor of upper lift; to floor of lower lift	17.0

Section 23



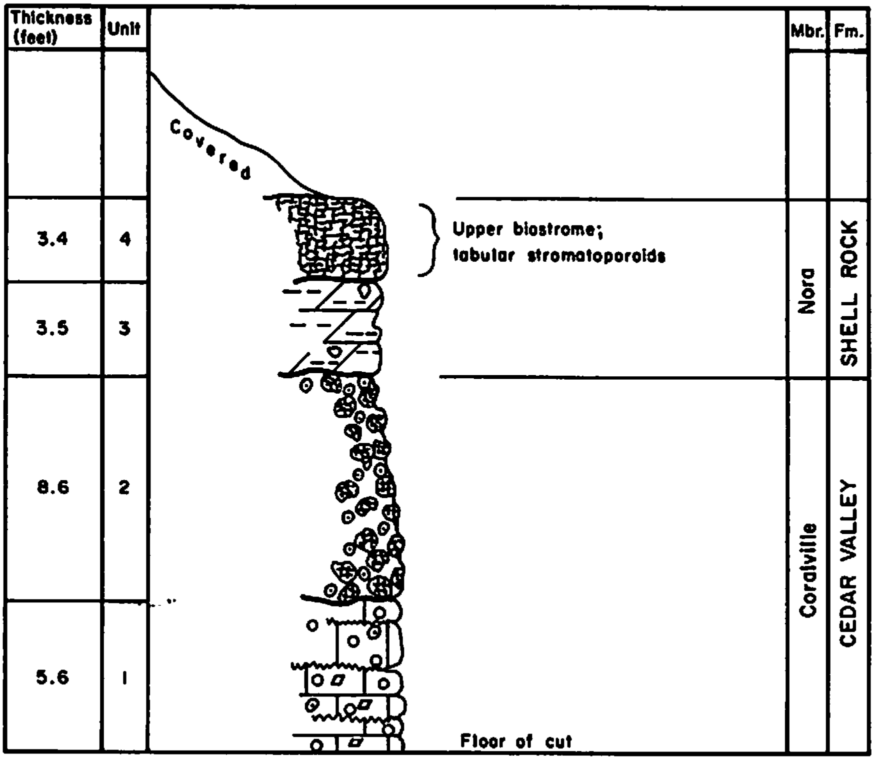
Section 23

PORTLAND RAILROAD TRESTLE ABUTMENT

East bank of Winnebago River; SE¼, SE¼, NW¼, SE¼, Sec. 18, T. 96 N., R. 19 W., Cerro Gordo County, Iowa.

Unit	Description	Thickness (feet)
	Devonian System	
	Shell Rock Formation	
	Nora Member	
4	Limestone biostrome, very pale-orange, composed of colonies of tabular stromatoporoids; distinct lower contact; massive	1.6
3	Dolomite, yellowish-orange to pale yellowish-brown, medium crystalline, subhedral, calcareous; small calcite-lined vugs averaging 2 inches in diameter are common; slightly broken beds; broadly undulating lower contact; thick-bedded	3.6
	Cedar Valley Formation	
	Coralville Member	
2	Limestone, very light-gray to pale-orange, sublithographic, pelletiferous zones; abundant calcisphere structures averaging ⅛mm in diameter; a few subspherical stromatoporoids and *Amphipora;* bedding plane concentration of small subspherical stromatoporoids and *Amphipora* 2.9 feet above base; numerous stylolite seams; broadly undulating upper and lower contacts; thick- to massive-bedded	6.8
1	Dolomite, pale to dark yellowish-brown, medium crystalline, slightly calcareous; a few subspherical stromatoporoids 1.2 feet below top; thick- to massive-bedded; to water	3.9

Section 24



Section 24

DECKER DRAINAGE CUT

About 500 feet west of Winnebago River, Near Ctr. south line SW¼, Sec. 34, T. 97 N., R. 20 W., Cerro Gordo County, Iowa.

Unit	Description	Thickness (feet)
	Devonian System	
	Shell Rock Formation	
	Nora Member	
4	Limestone biostrome, composed almost entirely of colonies of tabular stromatoporoids (pale-orange) in a matrix of dark yellowish-orange to light-brown, finely crystalline, slightly argillaceous, dolomitic limestone; massive	3.4
3	Dolomite, grayish-orange to dark yellowish-orange, medium crystalline, subhedral, very calcareous, argillaceous; small calcite-lined vugs and irregular veinlets of calcite; slightly broken beds; massive- to thick-bedded	3.5
	Cedar Valley Formation	
	Coralville Member	
2	Limestone biostrome, composed almost entirely of subspherical stromatoporoids and *Amphipora;* stromatoporoids are very pale-orange to very pale yellowish-brown, in a matrix of grayish-orange to very pale yellowish-brown, finely crystalline, slightly dolomitic limestone; portions of a few stromatoporoids are calcitized; moderately undulating upper and lower surfaces; weathers to a rough knobby surface; massive	8.6
1	Limestone, very pale-orange to light yellowish-gray, sublithographic, variably pelletiferous; abundant calcisphere structures averaging ⅛mm in diameter; trace of *Amphipora;* numerous stylolite seams; "floating" medium crystalline dolomite(?) rhombs in lower part; thick-bedded; to water	5.6

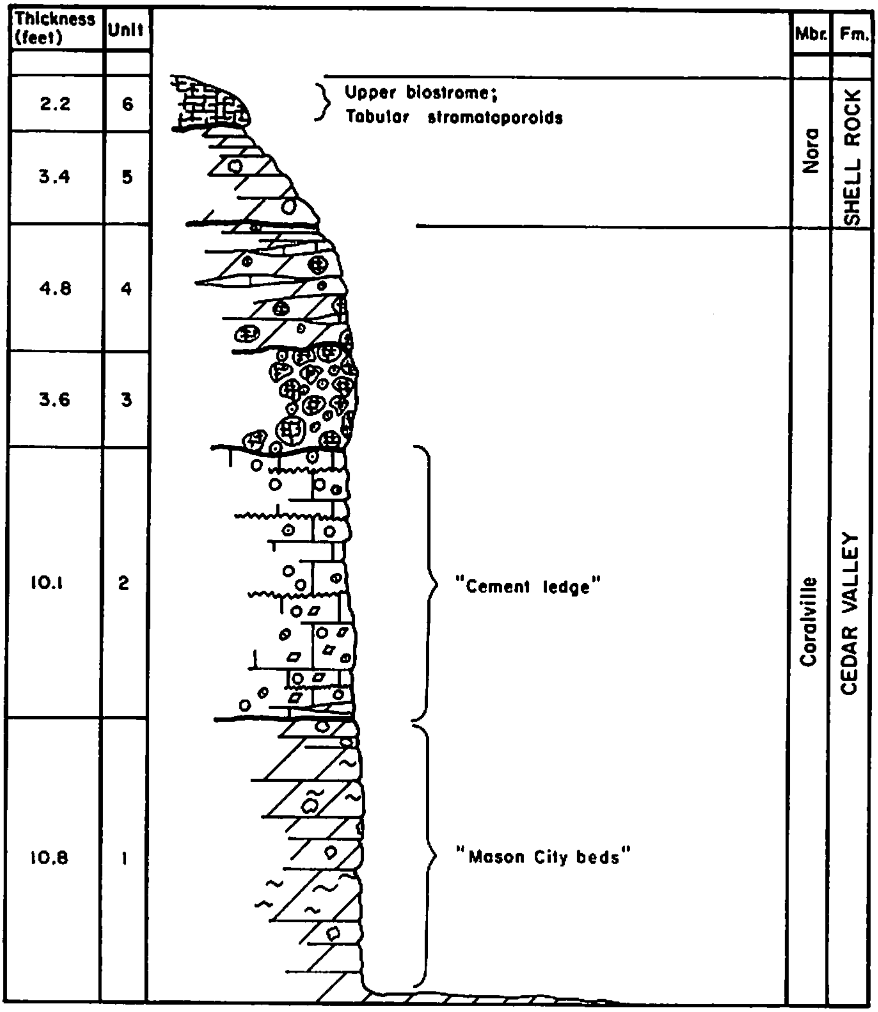
Section 25

IDEAL QUARRY

North side of slough, SW¼, SW¼, Sec. 35, T. 97 N., R. 20 W., Cerro Gordo County, Iowa.

Unit	Description	Thickness (feet)
	Devonian System	
	Shell Rock Formation	
	Nora Member	
5	Limestone biostrome, composed of tabular stromatoporoids (very pale-orange) in matrix of grayish-orange to dark yellowish-orange, medium crystalline, calcareous, dolomite; iron-stained; undulating lower surface; broken, massive bed	5.7
4	Dolomite, pale yellowish-brown to grayish-orange, medium crystalline, subhedral, very calcareous, variably argillaceous; iron-stained; small calcite-lined vugs common; undulating upper and lower surfaces; thick-bedded	4.6
	Cedar Valley Formation	
	Coralville Member	
3	Limestone biostrome, composed almost entirely of subspherical stromatoporoids and *Amphipora;* stromatoporoids are very pale-orange, in a matrix of grayish-orange, finely crystalline, slightly dolomitic limestone; moderately undulating lower surface; massive	5.5
2	Limestone, light grayish-orange to light yellowish-gray, sublithographic, variably pelletiferous; abundant calcisphere structures averaging ⅛mm in diameter; a few small subspherical stromatoporoids; *Amphipora* common; numerous stylolite seams; "floating" medium crystalline dolomite(?) rhombs in lower part; thick- to massive-bedded	10.5
1	Dolomite, pale to dark yellowish-brown, medium crystalline, subhedral, very slightly calcareous; zones with "vermicular" porosity are remains of calcitized and dissolved *Amphipora;* scattered calcitized and/or dolomitized subspherical stromatoporoids; massive- to thick-bedded; to quarry floor	9.7

Section 26


Thickness (feet)
Unit
Mbr.
Fm.
2.2
6
3.4
5
4.8
4
3.6
3
10.1
2
10.8
1
Upper biostrome;
Tabular stromatoporoids
"Cement ledge"
"Mason City beds"
Nora
Coralville
SHELL ROCK
CEDAR VALLEY

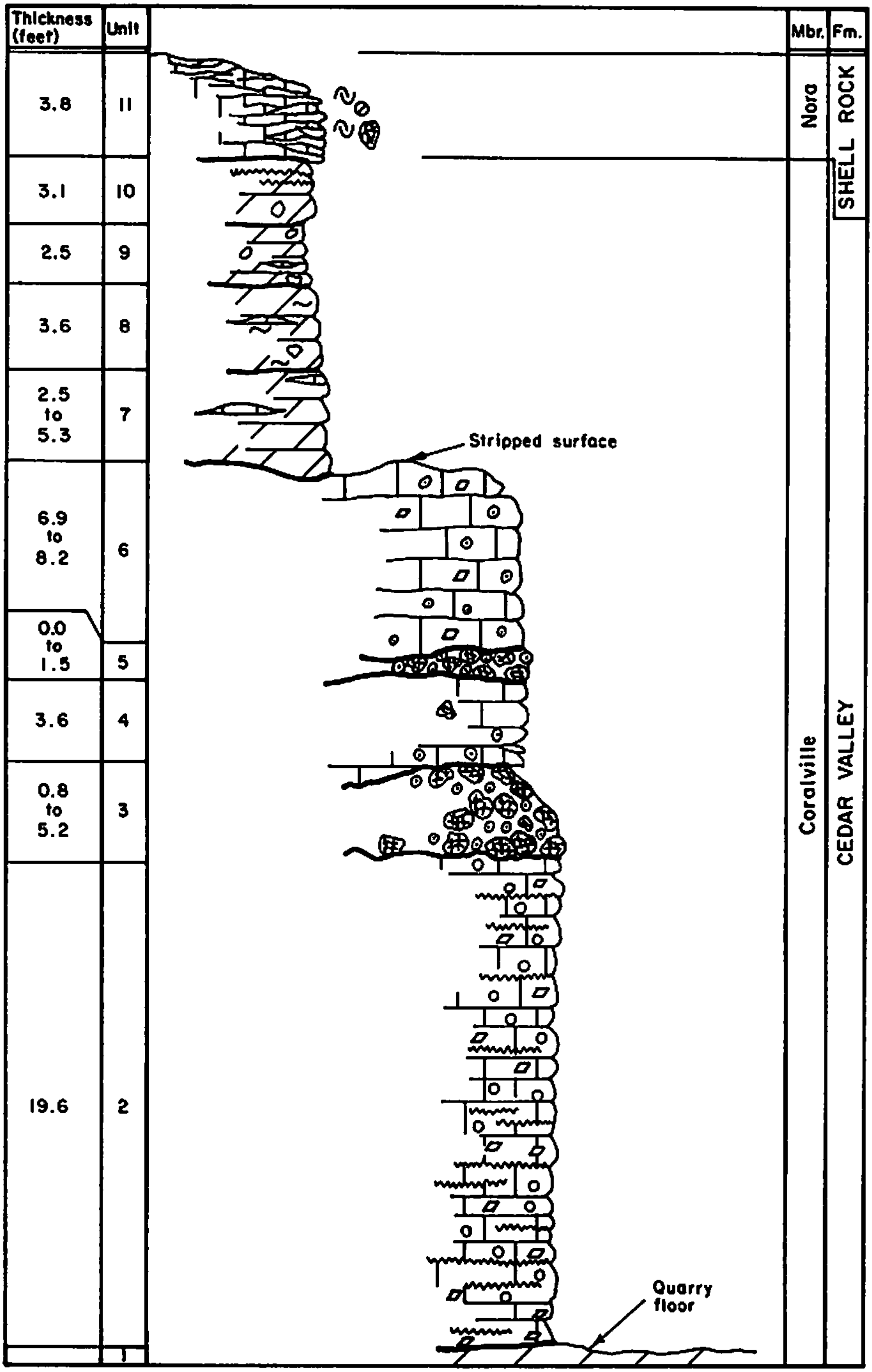
Section 26

WEAVER'S QUIMBY QUARRY

North of Winnebago River; NW¼, NW¼, Sec. 27, T. 97 N., R. 20 W., Cerro Gordo County, Iowa.

Unit	Description	Thickness (feet)
	Devonian System	
	Shell Rock Formation	
	Nora Member	
6	Limestone biostrome, composed almost entirely of colonies of tabular stromatoporoids (pale-orange) in a matrix of dark yellowish-orange, finely crystalline, dolomitic limestone; present only near middle of north face; massive ..	2.2
5	Dolomite, dark yellowish-orange to very pale yellowish-brown, medium to coarsely crystalline, calcareous; small calcite-filled vugs common; weathers to friable dolomite sand; massive- to thick-bedded; present only on north face ...	3.4
	Cedar Valley Formation	
	Coralville Member	
4	Dolomite, similar to bed 5 but with zones of very pale-orange to grayish-orange sublithographic, moderately pelletiferous limestone containing numerous calcisphere structures averaging ⅛mm in diameter; abundant *Amphipora;* small subspherical stromatoporoids common; massive	4.8
3	Limestone biostrome, composed dominantly of subspherical stromatoporoids (very pale-orange), *Amphipora,* and a few horn corals; in a matrix of finely crystalline, slightly argillaceous, dolomitic limestone; massive; irregular upper and lower contact	3.1 - 4.2
2	Limestone, medium light-gray to yellowish-gray and pale grayish-orange, sublithographic, variably pelletiferous; *Amphipora* common; abundant calcisphere structures averaging ⅛mm in diameter; "floating" medium crystalline dolomite(?) rhombs in lower part, increasing toward base; numerous stylolite seams; thick- to massive-bedded	8.7-11.5
1	Dolomite, dark to pale yellowish-brown, medium crystalline, slightly calcareous; scattered calcite-filled vugs in upper part (calcitized subspherical stromatoporoids); "vermicular" porosity the result of calcitization and solution of *Amphipora;* thick- to massive-bedded; to quarry floor	10.8

Section 27


Thickness (feet)
Unit
Mbr.
Fm.
3.8
11
3.1
10
2.5
9
3.6
8
2.5 to 5.3
7
6.9 to 8.2
6
0.0 to 1.5
5
3.6
4
0.8 to 5.2
3
19.6
2
1
Stripped surface
Quarry floor
Nora
Coralville
SHELL ROCK
CEDAR VALLEY

Section 27

LEHIGH PORTLAND CEMENT COMPANY QUARRY

Section measured near southwest corner of quarry; SW¼, SE¼, Sec. 13, T. 97 N., R. 21 W., Cerro Gordo County, Iowa.

Unit	Description	Thickness (feet)
	Devonian System	
	Shell Rock Formation	
	Nora Member	
11	Limestone, very pale-orange to pale grayish-orange, very finely crystalline; a few discontinuous stylolite seams; fossils include *Cyrtospirifer whitneyi*, *Atrypa* sp., *Aulopora* sp., charophyte oogonia (*Trochiliscus* sp.), high- and low-spired gastropods, a few small subspherical stromatoporoids and rugose corals, crinoid fragments, and orthoceraconic cephalopods (very rare); sharp lower contact; thick-bedded; present only in southwest part of quarry	3.8
	Cedar Valley Formation	
	Coralville Member	
10	Dolomite, moderate to dusky yellowish-brown, medium crystalline, subhedral, very slightly calcareous; a few small calcite-filled vugs; closely spaced stylolite seams in middle; zones with finely disseminated pyrite; moderately undulating base; massive	2.9 - 3.3
9	Dolomite, pale to dark yellowish-brown, medium crystalline, subhedral, very tough; numerous calcite-filled vugs from 2 to 5 inches across; moderately undulating upper and lower surfaces; thick-bedded	2.3 - 2.8
8	Dolomite, pale yellowish-brown, with zones of medium dark-gray mottling, medium crystalline, subhedral, very tough; a few small calcite-filled vugs; abundant "vermicular" openings averaging 1.5mm in diameter and 2 inches in length (calcitized and dissolved *Amphipora*); sharp upper and lower contacts; massive	3.6
7	Dolomite, pale to dusky yellowish-brown, medium crystalline, subhedral, moderately calcareous; very tough; subspherical stromatoporoids common, averaging 6 inches in diameter (generally calcitized); highly undulating lower surface; massive	2.5 - 5.3
	Note: unaltered lenses of yellowish-gray to medium light-gray, sublithographic, calcisphere-bearing limestone occur within the above dolomite units.	
6	Limestone, yellowish-gray to very pale-orange and medium gray, weakly mottled, sublithographic to lithographic; calcisphere structures averaging ⅛mm in diameter common; *Amphipora* and ostracodes abundant, very few small subspherical stromatoporoids; zones with "floating" medium crystalline dolomite(?) crystals; irregular upper and lower contacts; massive	6.9 - 8.2
5	Limestone biostrome, yellowish-gray and dark-gray, mottled, composed of slightly broken subspherical stromatoporoids and *Amphipora* in a matrix of pale-green clay; stromatoporoid fragments from 1 to 3 inches across; one discontinuous bed	0.0 - 1.5
4	Limestone, yellowish-gray to medium light-gray, sublithographic; zones with mixed grayish-green clay in upper part; a few 2 to 3 inch-diameter subspherical stromatoporoids; numerous *Amphipora* in lower part; thick-bedded	3.6
3	Limestone biostrome, as in bed 5; subspherical stromatoporoids average 5 inches in diameter; variable thickness; one bed	0.8 - 5.2
2	Limestone, very pale-orange to light-gray, sublithographic; calcisphere structures averaging ⅛mm in diameter very abundant; numerous stylolite seams; "floating" medium crystalline dolomite(?) crystals (zones with heavier concentrations); thick- to massive-bedded; to quarry floor	19.6
1	Quarry floor: dolomite, pale to dark yellowish-brown, medium crystalline, moderately calcareous; trace of scattered carbonaceous(?) flecks.	

APPENDIX II

WELL LOGS

Numbers following owner's name, for example W-9845, are Iowa Geological Survey reference numbers.

RUDD TOWN WELL, W-9845, 1958, Center north line, SW¼, Sec. 18, T. 96 N., R. 17 W., Floyd County, Iowa.

Interval (feet)	Description	Thickness (feet)
	Pleistocene	
0-25	Glacial drift	25
	Devonian System	
	Shell Rock Formation	
	Rock Grove Member	
25-30	Limestone, very pale yellowish-brown to light olive-gray, finely crystalline, moderately argillaceous, dolomitic zones; a few brachiopod fragments	5
30-34	Limestone, very pale yellowish-brown, finely crystalline, argillaceous, slightly dolomitic; trace of brachiopod and crinoid fragments	4
34-36	Limestone, pale yellowish-brown, sublithographic, subconchoidal fracture; trace of ostracode valves	2
	Mason City Member	
36-46	Limestone, pale yellowish-brown to olive-gray, very finely crystalline, argillaceous zones; abundant crinoid fragments, numerous ostracodes, trace of subspherical stromatoporoids and charophyte oogonia (*Trochiliscus* sp.)	10
46-50	Limestone biostrome(?), very pale yellowish-brown, composed of subspherical stromatoporoids and a few corals (galleries of stromatoporoids filled with calcite)	4
	Cedar Valley Formation	
	Coralville Member	
50-65	Limestone, pale-orange, weakly mottled with light-gray, lithographic to sublithographic; a few calcisphere structures from 1/8 to 1/16mm in diameter; scattered ostracode valves and very few *Amphipora*	15

FULLERTON ESTATE WELL, W-11541, SE Cor., SW¼, SE¼, NW¼, Sec. 30, T. 95 N., R. 18 W., Floyd County, Iowa.

Interval (feet)	Description	Thickness (feet)
	Pleistocene	
0-5	Glacial drift	5
	Devonian System	
	Lime Creek Formation	
	Cerro Gordo Member	
5-55	Limestone, light grayish-brown, finely crystalline, moderately to very argillaceous; interbedded with light-gray, soft, blocky, calcareous shale; very fossiliferous, including brachiopods, crinoid fragments, bryozoans and corals; charophyte oogonia in lower ten feet; upper 15 feet highly weathered and oxidized	50
	Juniper Hill Member	
55-120	Shale, light-gray to light olive-gray, blocky to weakly laminated, dolomitic in upper part, calcareous in lower part; spore carps common in lower ten feet	65
	Shell Rock Formation	
	Nora Member	
120-125	Limestone biostrome, yellowish-gray to light-gray, composed of colonies of tabular stromatoporoids; weak to moderate porosity where galleries of stromatoporoids are not filled with calcite	5
	Rock Grove Member	
125-127	Dolomite, pale yellowish-brown, medium crystalline, subhedral, very slightly calcareous ...	2
127-134	Dolomite, greenish-gray, medium crystalline, very argillaceous, shaly zones; grading to shale in lower part	7

Fullerton Estate Well (Continued)

Interval (feet)	Description	Thickness (feet)
134-135	Limestone, light yellowish-gray, very finely crystalline; olive-gray shale partings; ostracodes common	1
	Mason City Member	
135-145	Limestone, light olive-gray to pale yellowish-brown, finely crystalline, moderately to very argillaceous; scattered crinoid and brachiopod fragments; finely disseminated carbonaceous(?) flecks	10
	Cedar Valley Formation	
	Coralville Member	
145-160	Limestone, pale-orange to pale yellowish-brown, very finely crystalline, dolomitic zones; few ostracodes; traces of calcisphere structures averaging ⅛mm in diameter	15
160-	Dolomite, pale yellowish-brown, finely crystalline, anhedral to subhedral, slightly calcareous, slightly silty; scattered carbonaceous flecks ..	

STAUDT WELL, W-17056, SE¼, SE¼, NE¼, NE¼, Sec, 28, T. 95 N., R. 17 W., Floyd County, Iowa.

Interval (feet)	Description	Thickness (feet)
	Pleistocene	
0-35	Glacial drift	35
	Cretaceous System	
	Dakota Group	
	Dakota Sandstone ?	
35-45	Sandstone, dark yellowish-orange to pale yellowish-orange, very fine to medium sand-sized, very calcareous, argillaceous, very silty, composed of subangular to subrounded and rounded quartz grains, major grade 1/8 to 1/16mm; weak calcite cement, localized iron-oxide cementation, friable; interbedded or mixed with clayey, calcareous siltstone; scattered mica flakes	10
45-50	Sandstone, pale yellowish-orange, very coarse to very fine sand-sized, composed of subrounded to rounded and subangular frosted quartz grains, and a few slightly polished chert grains; dominantly free, little calcareous cement, some localized iron-oxide cementation; small amount of mixed reddish-orange shale in lower part	5
50-55	Shale, reddish-orange and pale yellowish-orange, very weakly laminated, moderately calcareous; slightly sandy; scattered mica flakes	5
	Devonian System	
	Shell Rock Formation	
	Mason City Member	
55-61	Limestone, pale-orange, very finely crystalline, with argillaceous and slightly dolomitic zones; fossils include crinoid fragments, brachiopods and a few ostracodes	6

Staudt Well (Continued)

Interval (feet)	Description	Thickness (feet)
61-65	Dolomite, light grayish-orange, finely crystalline, very calcareous; some pin-point porosity; free calcite	4
65-70	Dolomite, light grayish-orange, finely crystalline, slightly calcareous; small voids result of solution of fossil fragments; abundant unaltered crinoid fragments	5
	Cedar Valley Formation	
	Coralville Member	
70-76	Limestone, very pale-orange, lithographic; a few calcisphere structures ⅛mm in diameter; mottled with pale yellowish-orange, finely crystalline, subhedral to euhedral, calcareous dolomite which fills borings(?) and irregular cracks and voids	6

STABENOW WELL, W-8386, NW¼, SW¼, NW¼, NW¼, Sec. 3, T. 93 N., R. 18 W., Butler County, Iowa.

Interval (feet)	Description	Thickness (feet)
	Pleistocene	
0-100	Glacial drift	100
	Devonian System	
	Lime Creek Formation	
	Juniper Hill Member	
100-120	Shale, light-gray, blocky to weakly laminated, slightly calcareous; trace of pyrite; spore carps in lower five feet	20
	Cedar Valley Formation	
	Coralville Member	
120-135	Limestone, very pale-orange, sublithographic, with very light grayish-orange, dolomitic zones; 40 percent of cuttings are subspherical stromatoporoids which may be scattered throughout the bed or may be part of a distinct biostrome	15
135-146	Limestone, very light yellowish-gray to white, sublithographic, "floating", dolomite crystals; a few stromatoporoid fragments, and calcisphere structures averaging ⅛mm in diameter	11
146-150	Dolomite, very pale yellowish-brown, medium crystalline, slightly calcareous, slightly porous; calcite lining small voids	4
150-161	Limestone, very pale-orange, very finely crystalline to sublithographic, scattered "floating" dolomite hedra; mixed and/or interbedded with pale yellowish-brown medium crystalline, calcareous dolomite; a few stromatoporoid fragments	11

JOHANNS WELL, W-18062, SE¼, SE¼, SW¼, Sec. 14, T. 98 N., R. 19 W., Worth County, Iowa.

Interval (feet)	Description	Thickness (feet)
	Pleistocene	
0-15	Glacial drift	15
	Devonian System	
	Cedar Valley Formation	
	Coralville Member	
15-25	Limestone, light grayish-orange, sublithographic to lithographic, weakly pelletiferous; a few scattered *Amphipora*; abundant calcisphere structures averaging ⅛mm in diameter	10
25-32	Dolomite, grayish-orange, medium crystalline, subhedral to anhedral; calcitic; porous zones . .	7
32-36	Dolomite, very pale yellowish-brown, finely crystalline, subhedral to anhedral, slightly calcareous; trace of calcspar, probably derived from calcite-lined vugs	4
36-41	Dolomite, light olive-gray, medium crystalline, slightly silty, calcareous, and argillaceous; a few scattered carbonaceous or bituminous flecks	5
41-45	Dolomite, light greenish-gray, medium crystalline, silty, slightly calcareous, slightly argillaceous; finely disseminated pyrite	4
45-50	Dolomite, pale to dark yellowish-brown, medium crystalline, slightly calcareous; trace of pyrite and calcspar	5
50-55	Limestone, light yellowish-gray to light-gray very finely crystalline to sublithographic; zones with weak outlines of ¼ to ⅛mm dolomite(?) crystals; trace of *Amphipora*(?).	5

MASON CITY, City well 14, W- 8079, NE Corner Sec. 15, T. 96 N., R. 20 W., Cerro Gordo County, Iowa.

Interval (feet)	Description	Thickness (feet)
	Pleistocene	
0-10	Glacial drift	10
	Devonian System	
	Lime Creek Formation	
	Juniper Hill Member	
10-19	Shale, light grayish-orange and very light-gray, mixed, lumpy, slightly calcareous; trace of spore carps	9
	Shell Rock Formation	
	Nora Member	
19-25	Limestone biostrome, very pale-orange to very pale yellowish-brown, composed dominantly of colonies of tabular stromatoporoids; scattered dolomite crystals in galleries of stromatoporoid; highly dolomitic zones between some stromatoporoid lamellae	6
25-30	Dolomite, pale yellowish-brown, medium crystalline, slightly argillaceous, calcareous	5
	Cedar Valley Formation	
	Coralville Member	
30-36	Limestone biostrome, very pale-orange to medium light-gray, composed almost entirely of subspherical stromatoporoids and *Amphipora*; subspherical stromatoporoids are colored very pale-orange, *Amphipora* are generally light-gray; matrix is light-gray, finely crystalline, dolomitic limestone to medium light-gray, medium crystalline, subhedral, calcareous dolomite	6

Mason City, City Well 14 (Continued)

Interval (feet)	Description	Thickness (feet)
36-49	Limestone, yellowish-gray to very pale orange, sublithographic, variably pelletiferous; calcisphere structures averaging ⅛mm in diameter very abundant; *Amphipora* common, trace of subspherical stromatoporoids; few small voids filled with calcite and minor pyrite; medium crystalline "floating" dolomite(?) crystals abundant in lower 4 feet	13
49-60	Dolomite, pale yellowish-brown to light brownish-gray, medium crystalline, subhedral, slightly calcareous; trace of "vermicular" porosity (calcitized and dissolved *Amphipora*)	11

MASON CITY, City Well 12, W-2971, NE¼, SE¼, NE¼, SE¼, Sec. 16, T. 96 N., R. 20 W., Cerro Gordo County, Iowa.

Interval (feet)	Description	Thickness (feet)
	Pleistocene	
0-7	Glacial drift	7
	Devonian System	
	Lime Creek Formation	
	Cerro Gordo Member	
7-13	Dolomite, grayish-orange to pale yellowish-orange, finely to medium crystalline, anhedral to subhedral, very calcareous, very argillaceous, shaly zones	6
13-20	Dolomite, light olive-gray to brownish-gray, finely crystalline, moderately argillaceous, calcareous; finely disseminated pyrite	7
	Juniper Hill Member	
20-35	Shale, very light olive-gray, blocky, slightly calcareous to weakly dolomitic	15
35-42	Shale, as above, interbedded with medium-gray to light olive-gray, finely crystalline, argillaceous, calcareous, silty dolomite	7
42-70	Shale, very light olive-gray, soft, lumpy, slighty dolomitic; spore carps in lower 10 feet	28
	Shell Rock Formation	
	Nora Member	
70-77	Tabular stromatoporoid biostrome, grayish-brown to very pale yellowish-brown (stromatoporoids lighter-colored), altered to medium crystalline, slightly calcareous dolomite (stromatoporoid structures still recognizable); trace of pyrite	7

Mason City, City Well 12 (Continued)

Interval (feet)	Description	Thickness (feet)
	Cedar Valley Formation	
	Coralville Member	
77-85	Subspherical stromatoporoid biostrome, medium-gray and pale-orange (stromatoporoids lighter-colored), altered to medium crystalline, subhedral, slightly calcareous dolomite (stromatoporoids still recognizable); calcite in vugs	8
85-101	Limestone, yellowish-gray to very light-gray, sublithographic, weakly pelletiferous zones; calcisphere structures averaging ⅛mm in diameter very abundant; trace of *Amphipora* and subspherical stromatoporoids; stylolite seams; "floating" medium crystalline dolomite(?) crystals in lower part	16
101-114	Dolomite, pale to dusky yellowish-brown, medium crystalline, subhedral; carbonaceous(?) flecks in darker-colored zones; free calcspar ..	13
114-118	Dolomite, light olive-gray, finely crystalline, anhedral, argillaceous, slightly calcareous ...	4

HEBEL WELL, W-13981, NE¼, NE¼, SE¼, NE¼, Sec. 25, T. 97 N., R. 20 W., Cerro Gordo County, Iowa.

Interval (feet)	Description	Thickness (feet)
	Pleistocene	
0-45	Glacial drift	45
	Devonian System	
	Lime Creek Formation	
	Cerro Gordo Member	
45-46	Limestone, light yellowish-gray, very finely crystalline, argillaceous	1
	Juniper Hill Member	
46-85	Shale, very light olive-gray to light-gray, blocky, slightly dolomitic; crushed spore carps common in lower 15 feet	39
	Shell Rock Formation	
	Nora Member(?)	
85-90	No samples recovered; this interval may be the upper tabular stromatoporoid biostrome of the Nora	5
90-95	Dolomite, dark yellowish-brown, medium crystalline; trace of subspherical stromatoporoids; free calcite; this interval is probably the equivalent of the middle argillaceous beds of the Nora	5
	Cedar Valley Formation	
	Coralville Member	
95-100	No samples recovered; this interval may be the subspherical stromatoporoid biostrome of the Coralville	5

Hebel Well (Continued)

Interval (feet)	Description	Thickness (feet)
100-111	Limestone, yellowish-gray, sublithographic; packed with calcisphere structures averaging ⅛mm in diameter; *Amphipora* rare; stylolite seams common; medium crystalline dolomite (?) crystals in lower part; this is the "cement ledge" lithology of the Mason City area	11
111-	Dolomite, very pale yellowish-brown, medium crystalline, subhedral to anhedral, calcareous; this is the interval of the "Mason City beds" of the Mason City area.	

MATSON WELL, W-9308, SE¼, SE¼, NE¼, Sec. 19, T. 97 N., R. 21 W., Cerro Gordo County, Iowa.

Interval (feet)	Description	Thickness (feet)
	Pleistocene	
0-70	Glacial drift	70
	Devonian System	
	Lime Creek Formation	
	Cerro Gordo Member	
70-75	Dolomite, pale yellowish-brown, medium crystalline, anhedral to subhedral, slightly calcareous	5
	Juniper Hill Member	
75-120	Shale, very light-gray, weakly laminated to blocky, slightly dolomitic; spore carps common in lower 10 feet	45
	Cedar Valley Formation	
	Coralville Member	
120-125	Limestone, light yellowish-gray, sublithographic; a few ostracode fragments and traces of subspherical stromatoporoids; calcisphere structures averaging ⅛mm in diameter are common; stylolite seams present; this is the "cement ledge" lithology of the Mason City area	5
125-140	Dolomite, pale yellowish-brown, and medium light-gray; medium crystalline, subhedral to anhedral, slightly calcareous; scattered carbonaceous(?) flecks in upper 5 feet; free calcspar and calcite-lined vugs; this is the interval of the "Mason City beds" of the Mason City area	15

APPENDIX III

CORE DESCRIPTIONS

Core 1

ANDREWS PROPERTY CORE

West of Winnebago River, SW¼, NE¼, SE¼, Sec. 36, T. 96 N., R. 19 W., Cerro Gordo County, Iowa; description of beds and correlations as recorded by Iowa State Highway Commission, with added notations by author.

Unit	Description	Thickness (feet)
	Devonian System	
	Shell Rock Formation	
	Nora Member	
1	Limestone, light-gray, fine-grained to sublithographic; hard and soft zones; a mass of laminar stromatoporoids	6.0
2	Shale, buff to greenish-blue, magnesian	5.3
3	Limestone, brownish-gray to gray, medium-grained to sublithographic; earthy texture; numerous hard, black, wavy shale partings; gradational base	2.6
4	Shale, blue-gray, magnesian	0.7
5	Limestone, cream with brown and black mottling; a mass of laminar stromatoporoids; very hard; some clay around the stromatoporoids ..	3.9
	Rock Grove Member	
6	Dolomite and shale:	
	6A) Dolomite, brown to dark-gray, finely crystalline; hard; numerous green siltstone inclusions	2.6
	6B) Shale, bluish-gray, magnesian; hard, silty; gradational contact at base	5.4
7	Dolomite, brown, with numerous incipient black shale partings; some lighter colored cal-	

Core 1 (Continued)

Unit	Description	Thickness (feet)
	citic zones composed of a fossil hash; fine-grained to very finely crystalline; hard; two massive beds	5.9
8	Limestone, light-gray, fine-grained, argillaceous; hard; 0.2-foot beds interbedded with dark-brown, calcareous shale of the same thickness; irregular contact at base	3.2
	Mason City Member	
9	Limestone, dark grayish-brown with white fossil markings, fine-grained, dolomitic; hard; numerous incipient black shale partings; beds average 2.0 feet thick; numerous brachiopods, tetracorals, crinoidal zones and a few stromatoporoids	12.5
10	Dolomite, dark-gray, fine-grained, argillaceous; soft; very sharp contact at base	0.6
11	Limestone, cream to light-brown; almost completely composed of hard massive and laminar stromatoporoids surrounded by incipient black shale partings	7.1
	Note: The author believes the stromatoporoids in this bed are subspherical forms rather than laminar forms.	
	Cedar Valley Formation*	
	Coralville Member	
12	Limestone, cream, lithographic; blue-green clay fills and shale partings giving bed a brecciated appearance; sharp contact at base	3.2
13	Dolomite, dark greenish-gray at top to light-gray with black color laminations at base; fine-	

Core 1 (Continued)

Unit	Description	Thickness (feet)
	grained to very finely crystalline; hard; calcitic; grades into underlying bed	2.9
14	Dolomite, blue-gray with lighter color mottling which gives a brecciated appearance; earthy texture, argillaceous; gradational contact at base	1.9
15	Dolomite, dark-brown with blue-green mottling; very finely crystalline; very hard; minutely vesicular; lower 1.0-foot color laminated; massive sharp black stylolitic seam at base	4.1
16	Dolomite, brownish-gray with various shades of gray, brown and cream color mottling giving a brecciated appearance; medium to fine-grained to finely crystalline; hard; numerous fossil vugs; beds average 0.8-foot thick with black stylolites between; lower 3.0 feet with included green clay and finely clastic zones ...	9.7

*The author places the Shell Rock-Cedar Valley contact at the top of bed 12; in this description by the Iowa State Highway Commission the Shell Rock-Cedar Valley contact was placed at the top of bed 16.

Core 2

SHANKS PROPERTY CORE

Two miles northeast of Portland, SE¼, SE¼, SW¼, SE¼, Sec. 9, T. 96 N., R. 19 W., Cerro Gordo County, Iowa.

Unit	Description	Thickness (feet)
	Pleistocene	
1	Glacial drift	36.7
	Devonian System	
	Shell Rock Formation	
	Nora Member	
2	Limestone biostrome, very pale-orange, composed dominantly of tabular stromatoporoids; top 0.2 foot with irregular patches of dusky yellowish-green argillaceous dolomite; massive	7.3
3	Dolomite, light olive-gray, finely crystalline, anhedral, very argillaceous	0.8
4	Dolomite, dark yellowish-brown, medium to finely crystalline, subhedral; slightly porous; calcite-filled vug near bottom; thick-bedded	2.9
5	Dolomite, dark yellowish-brown to dark olive-gray, finely crystalline, argillaceous; calcite-lined vugs	2.8
	Cedar Valley Limestone	
	Coralville Member	
6	Dolomite, pale yellowish-brown to dark yellowish-brown, finely to medium crystalline, subhedral; scattered subspherical stromatoporoids and *Amphipora*; few calcite-filled vugs; numerous stylolite seams	15.3

Core 3

BURWELL PROPERTY CORE

West bank of tributary to Calmus Creek, NE¼, NE¼, NE¼, SE¼, Sec. 36, T. 97 N., R. 21 W., Cerro Gordo County, Iowa.

Unit	Description	Thickness (feet)
	Pleistocene	
1	Glacial drift	3.4
	Devonian System	
	Lime Creek Formation	
	Cerro Gordo Member	
2	Dolomite, yellowish-orange, medium crystalline, slightly calcareous, argillaceous; brachiopod molds; soft, broken beds	5.8
3	Dolomite, grayish-orange, finely crystalline, slightly calcareous, argillaceous; interbedded with bluish-gray shale	6.5
	Juniper Hill Member	
4	Shale, medium gray to medium bluish-gray, slightly dolomitic; lower 0.4 foot is medium dark-gray, finely crystalline, argillaceous dolomite with embedded coarse- to medium-grained quartz sand and abraded fish teeth (*Ptyctodus calceolus*	33.3
	Shell Rock Formation	
	Nora Member	
5	Dolomite, medium olive-gray to dark yellowish-brown, medium to finely crystalline; a few brachiopods and horn corals; carbonaceous clay partings; slightly vuggy; massive-bedded	3.5
6	Dolomite, medium-gray to light greenish-gray, finely crystalline; abundant *Cladopora*(?), *Amphipora* and small subspherical stromatoporoids	

Core 3 (Continued)

Unit	Description	Thickness (feet)
	below top 1.2 feet (fossils calcitized except for outer rim)	4.3
	Cedar Valley Limestone	
	Coralville Member	
7	Dolomite, very pale yellowish-brown, medium crystalline; prominent "vermicular" porosity (dissolved *Amphipora*)	2.0
8	Dolomite, pale yellowish-brown, medium crystalline; abundant subspherical stromatoporoids (calcitized centers, dolomitized rims); stylolite seam near top and base	3.1
9	Dolomite, dusky yellowish-brown to pale yellowish-brown, medium crystalline; mottled with burrow(?) markings	2.0
10	Dolomite, medium-gray, finely crystalline, very tough; moderate porosity	0.8

Core 4

MASON CITY BRICK AND TILE CLAY PIT

Western edge of Mason City, south of U. S. 18, SW¼, SE¼, NW¼, SW¼, Sec. 8, T. 96 N., R. 20 W., Cerro Gordo County, Iowa; core drilled in floor of pit one foot above base of Juniper Hill Shale.

Unit	Description	Thickness (feet)
	Devonian System	
	Lime Creek Formation	
	Juniper Hill Shale	
1	Shale, medium-gray to very light olive-gray, slightly dolomitic; a few crushed spore carps ..	1.0
2	Dolomite, light olive-gray, finely crystalline, calcareous, argillaceous; embedded coarse to very fine sand-sized quartz grains; abraded fish teeth abundant; soft, elongated phosphatic (?) grains 2mm in length	0.4
	Shell Rock Formation	
	Nora Member	
3	Dolomite, very dark yellowish-brown and pale yellowish-brown, mottled, medium crystalline, subhedral, slightly calcareous; packed with dolomitized *Amphipora* and *Cladopora*(?); scattered fragments of tabular(?) stromatoporoids; massive- to thick-bedded	4.6
4	Dolomite, very pale yellowish-brown and medium dark-gray, mottled, medium crystalline, subhedral, slightly calcareous; scattered tabular stromatoporoid laminae from ⅛ inch to ¼ inch thick; massive	2.7
	Cedar Valley Limestone	
	Coralville Member	
5	Dolomite, dark yellowish-brown in upper part, dark olive-gray in lower part, finely crystalline;	

Core 4 (Continued)

Unit	Description	Thickness (feet)
	scattered carbonaceous flecks; lower 2 feet fractured and broken; massive- to thick-bedded	5.7
6	Limestone, very light olive-gray, coarsely crystalline, with abundant embedded quartz sand and silt grains; zones with cross-laminations; 0.4-foot interval of very light olive-gray, sandy shale at top; irregular upper and lower contacts	4.8
7	Dolomite, medium-gray and yellowish-gray, mottled, medium crystalline, very calcareous; vuggy; thick-bedded	2.6
8	Limestone, medium-gray to very light olive-gray, very finely crystalline, pelletiferous; abundant calcisphere structures averaging ⅛mm in diameter; stylolite seams common; partially dolomitized in lower 2 feet	7.0
9	Dolomite, pale yellowish-brown, finely to medium crystalline, calcareous; "vermicular" porosity (*Amphipora* molds); massive- to thick-bedded	5.7

Core 5

STROTHER'S PROPERTY CORE

One-half mile northwest of Lincoln Mill site, NW¼, NW¼, SW¼, SE¼, Sec. 10, T. 97 N., R. 21 W., Cerro Gordo County, Iowa.

Unit	Description	Thickness (feet)
	Devonian System	
	Shell Rock Formation	
	Nora Member	
1	Dolomite, pale yellowish-brown to light-gray, medium crystalline, subhedral	1.1
2	Limestone, yellowish-gray, sublithographic; fossils include *Cyrtospirifer whitneyi, Aulopora, Atrypa*, gastropods, crinoid ossicles, small subspherical stromatoporoids, and charophyte oogonia (*Trochiliscus* sp.); a few "floating" medium crystalline dolomite(?) crystals; numerous stylolite seams	5.2
	Cedar Valley Formation	
	Coralville Member	
3	Dolomite, dusky yellowish-brown to dark yellowish-brown, medium crystalline, subhedral, slightly calcareous; alternating laminations of yellowish-brown and dark-gray dolomite with carbonaceous(?) flecks in upper part; intercalated greenish-gray clay in lower 0.6 foot; sharp upper and lower contacts	1.7
4	Dolomite, pale to dark yellowish-brown, medium crystalline, subhedral; very tough; zones of "vermicular" porosity (calcitized and dissolved *Amphipora*); recognizable *Amphipora* in lower part; stylolite seams common; 0.3-foot light olive-gray clay seam at base; thick- to massive-bedded	10.3

Core 5 (Continued)

Unit	Description	Thickness (feet)
5	Dolomite, medium light-gray and light olive-gray, weakly mottled, medium crystalline, calcareous; massive	3.8
6	Dolomite, pale yellowish-brown, medium crystalline, subhedral, porous; massive	2.7
7	Dolomite, light olive-gray and medium dark-gray, mottled, medium crystalline, calcareous; closely spaced stylolite seams	2.8
8	Limestone, medium light-gray and yellowish-gray, weakly mottled, sublithographic; calcisphere structures averaging ⅛mm in diameter common in upper part, very abundant in lower part; scattered small subspherical stromatoporoids and *Amphipora*, a few ostracodes; stylolite seams in upper part; thick- to massive-bedded	9.1
9	Limestone, light-gray to yellowish-gray, sublithographic; variably dolomitic, and with zones of pale yellowish-brown, medium crystalline, subhedral, calcareous dolomite; stylolite seams common in upper part; thick- to massive-bedded	14.2

PLATE I

STRUCTURAL PANEL DIAGRAM

DEVONIAN FORMATIONS
NORTH-CENTRAL IOWA