# THE PENNSYLVANIAN GEOLOGY OF SOUTH-CENTRAL IOWA

edited by
Thomas Marshall and Chad Fields


**Geological Society of Iowa**

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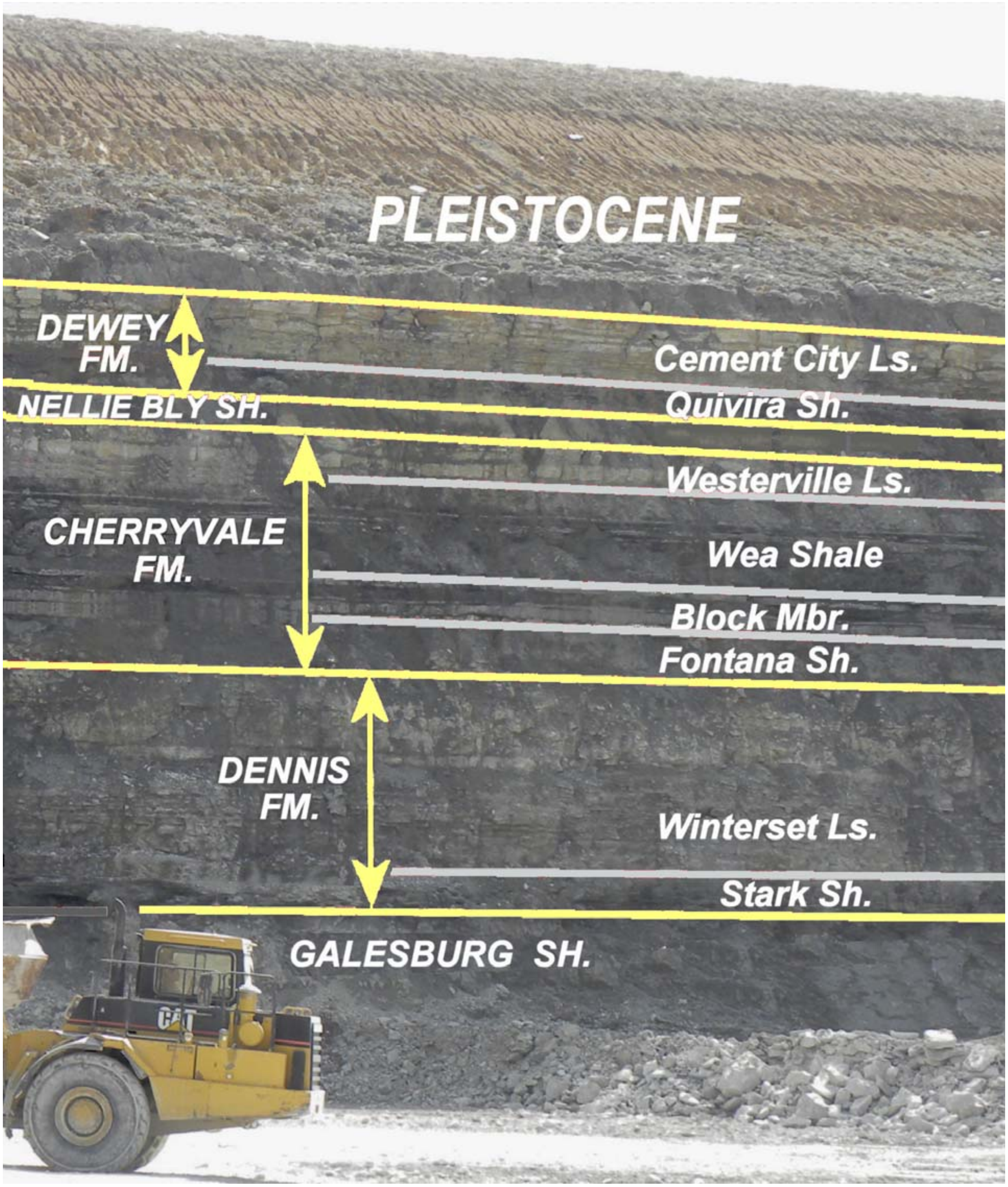


**Cover Photograph**

The cover photograph shows the Pennsylvanian succession exposed along the south high wall at Thayer Quarry, Union County. The annotated photo above displays the stratigraphy at the quarry, with formation names labeled in uppercase and member names labeled in title case. Photo by Brian Witzke.

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# INTRODUCTION TO THE PENNSYLVANIAN GEOLOGY OF SOUTH-CENTRAL IOWA

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**Figure 1.** Photograph (from left to right) of quarry operator Greg Schildberg, and John Pope (Northwest Missouri State University) and Iowa Geological & Water Survey Geologists Tom Marshall, Jason Vogelgesang, and Charles Monson in the Decatur City Quarry. photograph by field trip leader Brian Witzke

## INTRODUCTION

The 2010 Geological Society of Iowa spring field trip will examine the Pennsylvanian Geology in South-Central Iowa, specifically in and around Decatur County. We will be visiting two quarries operated by Schildberg Construction Company, Inc., headquartered in Greenfield, Iowa. Our field trip will have perhaps the most knowledgeable group of Iowa Pennsylvanian geologists ever assembled, including Dr. Phil Heckel (University of Iowa), and Drs. Brian Witzke and Tom Marshall (Iowa Geological and Water Survey). If these guys can't answer your question about the Pennsylvanian geology of Iowa, it is doubtful that anyone can. We will also have assistance from IGWS paleontologist Charles Monson, and we hope to be joined by geologist and Schildberg Construction Co vice president Greg Schildberg, who we thank for graciously providing us access to their quarries and assisting us in the planning of this field trip. Greg knows the geology of these quarries very well, plus he will be able to discuss the practical and economic aspects of operating a limestone quarry in the Pennsylvanian of Iowa.

## PENNSYLVANIAN

This field trip will concentrate on the geology of the Pennsylvanian Bronson and Kansas City groups. The first article in this guidebook is a discussion of the Pennsylvanian stratigraphy of the Bronson and Kansas City Group, part of a comprehensive discussion of Iowa's Pennsylvanian stratigraphy prepared by John Pope to be included in an on-line Lexicon of Iowa Geology that is currently in preparation. Supplementary material and photographs were prepared by Tom Marshall, Brian Witzke, and Jason Vogelgesang. The second article is a discussion by Charles Monson of the fossils that we may see in these strata.

Our first stop will be at the Decatur City Quarry, located just off of Iowa Highway 2 west of the Decatur City exit on I-35. At this stop we will see rocks of the Pennsylvanian Bronson Group, including the Bethany Falls Limestone and Hushpuckney Shale members of the Swope Formation, the Galesburg Shale including the Davis City Coal Bed, and the Winterset Limestone and Stark Shale members of the Dennis Formation.

The second field trip stop will be about 15 miles northwest of the Decatur City Quarry at the Thayer Quarry, located in Union County just east of County Road P-64 about 5 miles south of Thayer. The Thayer Quarry exposes rocks of the upper Bronson and lower Kansas City groups, including the Galesburg Shale, Dennis, Cherryvale, Nellie Bly Shale, and Dewey formations (see front cover for photo of Thayer Quarry, and inside front cover for interpretations). These units include the Cement City, Westerville, and Winterset limestone members. We will spend extra time searching for fossils at stockpiles in the quarry. Fossils that can be collected are relatively abundant and include brachiopods, crinoids, bryozoans, bivalves, snails, and filled burrows.

## PLEISTOCENE

This guidebook also included a brief discussion by Brian Witzke of the Pleistocene geology of the region, including an excellent exposure of glacially striated limestone discovered by Greg Schildberg and described by the authors while they were scouting exposures for this guidebook. Unfortunately, time constraints will not allow us an opportunity visit this exposure during this field trip, but the GPS coordinates of the site are listed, so after gaining permission from the land owner, you may be able to visit the site on your own at another time.

The loess-capped Pre-Illinoian glacial tills that bury bedrock in most areas of southern Iowa are also exposed in the Decatur City and Thayer quarries. If conditions are favorable we may have an opportunity to examine the Pleistocene section in one or both of these quarries. Of particular interest are exposures of a prominent sand and gravel unit in the Thayer Quarry. Known as the Aftonian Gravel, this unit has yielded numerous Pleistocene vertebrate fossils

## ENJOY YOUR FIELD TRIP

**BUT, while you are in the quarries it is of critical importance that you follow the directions of the field trip leaders. You need to wear your hard hats and eye protection at all times, and you are not allowed to get near the high walls. Winter freeze-thaw cycles have loosened rocks and there is a great danger of being severely injured by falling rocks. Please respect the rules of the Schildberg Construction Company, who graciously allowed us access to their quarries.**

# PENNSYLVANIAN GEOLOGY OF DECATUR CITY AND THAYER QUARRIES

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## INTRODUCTION

Strata visible in Decatur City and Thayer Quarries (Upper Pennsylvanian Series, Missourian Stage) constitute clayey shales, limestones, mudstones, and dark fissile shales of the Bronson Group (above Pleasanton Formation) to the Kansas City Group (top of Dewey Formation) (Figure 1). Unlike the lower and middle Pennsylvanian, coals and sandstones are less common, and marine lithofacies are predominant. Limestones and shales were deposited in repeated packages by cycles of marine transgression and regression across the region, known as cyclothems. The following information has been incorporated from Pope's 2009 unpublished manuscript.

## THE MISSOURIAN STAGE IN IOWA

Keyes (1893) named the Missourian Stage for outcrops along the Missouri River in Missouri and Iowa, corresponding to the lower part of 'Upper Coal Measures' as defined by Broadhead (1873) and Winslow (1892). Jewett et al. (1968) placed the Missourian Stage into the Upper Pennsylvanian Series.

Keyes (1894) defined the Missourian Stage from above the Des Moines Series to the Cottonwood Limestone, and Kansas, Missouri, and Iowa geological surveys placed base of the Missourian at base of the Hertha Limestone. Moore (1932) redefined the Missourian from a shale between Exline and Hertha limestones to base of the Tonganoxie Sandstone in northeastern Kansas, essentially lower Missourian of Keyes, 1898. Landis and Van Eck (1965) recognized the base of the Chariton Conglomerate as base of the Missourian in Iowa. Heckel (1999), Heckel and others (1999), and Heckel and Watney (2002) placed the Desmoinesian/Missourian boundary at the base of the Exline Limestone of the Pleasanton Group of Kansas (Pleasanton Formation of Iowa), upon first appearance of the conodont *Idiognathodus eccentricus*. They placed the Missourian/Virgilian boundary within the Douglas Group, either at top of the Vinland Shale Member of the Stranger Formation or base of the Haskell Limestone Member of the Cass Limestone, upon first appearance of the conodont *Streptognathodus zethus*.

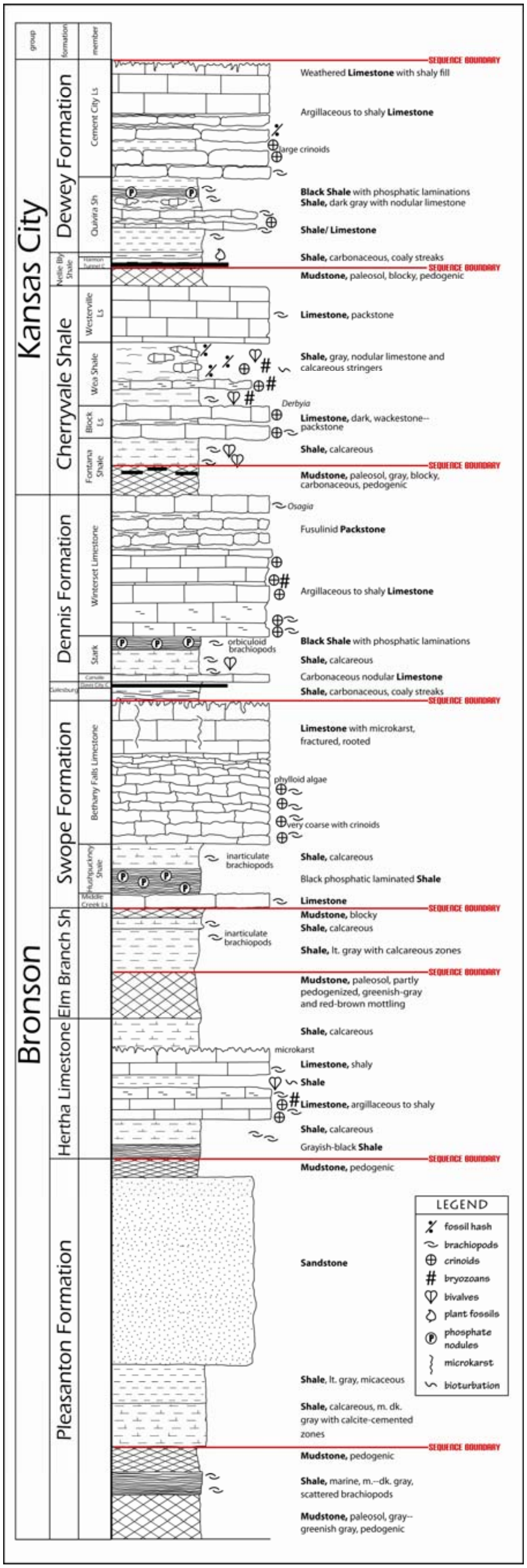


**Figure 1.** Composite graphic section of the stratigraphy (Upper Pennsylvanian Series, Missourian Stage) in the field study area. The Bethany Falls through the Cement City limestones can be seen at Decatur City and Thayer quarries. Based on cores from neighboring Ringgold County.

The Missourian Stage consists of the Stranger Formation of the Douglas Group; Lansing Group; Kansas City Group; and most of the Bronson Group. The Missourian overlies the Desmoinesian Stage of Middle Pennsylvanian Series and underlies Virgilian Stage of Upper Pennsylvanian Series (Figure 2). The thickness of the Missourian ranges from 500 ft (152 m) in Iowa to 650 ft (200 m) in Kansas.

**Landis & Van Eck (1965)**

| Series | Group | Subgroup | Formation | Member |
|---|---|---|---|---|
| Virgilian | Douglas | | Lawrence | |
| | | | Stranger | unnamed coal |
| Missourian | Lansing | | Stanton | South Bend<br>Rock Lake Sh<br>Stoner Ls<br>Eudora Sh<br>Captain Crk Ls |
| | | | Vilas Sh | |
| | | | Plattsburg | Spring Hill Ls<br>Hickory Crk Sh<br>Merriam Ls |
| | Kansas City | Zarah | Bonner Springs Sh | |
| | | | Wyandotte | Farley Ls<br>Island Crk Sh<br>Argentine Ls<br>Quindaro Sh<br>Frisbie Ls |
| | | | Lane Sh | |
| | | Linn | Iola | Raytown Ls<br>Muncie Crk Sh<br>Paola Ls |
| | | | Chanute Sh | |
| | | | Drum | Corbin City Ls<br>Cement City Ls |
| | | | Quivira Sh | |
| | | | Westerville Ls | |
| | | | Cherryvale Sh | Wea Sh<br>Block Ls<br>Fontana Sh |
| | | Bronson | Dennis | Winterset Ls<br>Stark Sh<br>Canville Ls |
| | | | Galesburg Sh | |
| | | | Swope | Bethany Falls Ls<br>Hushpuckney Sh<br>Middle Creek Ls |
| | | | Ladore Sh | |
| | | | Hertha | |
| | Pleasanton | | | Exline Ls<br>Ovid C<br>Chariton Congl |
| Desmoinesian | Marmaton | | Lenapah Ls | Cooper Crk Ls |

**Ravn and others (1984)**

| Group | Formation | Member |
|---|---|---|
| Douglas | Lawrence | |
| | Stranger | unnamed coal |
| Lansing | Stanton | South Bend<br>Rock Lake Sh<br>Stoner Ls<br>Eudora Sh<br>Captain Crk Ls |
| | Vilas Sh | |
| | Plattsburg | Spring Hill Ls<br>Hickory Crk Sh<br>Merriam Ls |
| Kansas City | Bonner Springs Sh | |
| | Wyandotte | Farley Ls<br>Island Crk Sh<br>Argentine Ls<br>Quindaro Sh<br>Frisbie Ls |
| | Lane Sh | |
| | Iola | Raytown Ls<br>Muncie Crk Sh<br>Paola Ls |
| | Chanute Sh | |
| | Drum | Corbin City Ls<br>Cement City Ls |
| | Cherryvale Sh | Quivira Sh<br>Westerville Ls<br>Wea Sh<br>Block Ls<br>Fontana Sh |
| Bronson | Dennis | Winterset Ls<br>Stark Sh<br>Canville Ls |
| | Galesburg Sh | |
| | Swope | Bethany Falls Ls<br>Hushpuckney Sh<br>Middle Creek Ls |
| | Ladore Sh | |
| | Hertha | Sniabar Ls<br>Mound City Sh |
| | Pleasanton | unnamed sh<br>Exline Ls<br>unnamed sh |
| Marmaton | Lost Branch | Cooper Crk Ls<br>unnamed sh<br>Sni Mills Ls |

**Pope (2008)**

| Stage | Group | Formation | Member *bed* |
|---|---|---|---|
| Virgilian | Douglas | Cass | Shoemaker Ls<br>Little Pawnee Sh<br>Haskell Ls |
| Missourian | | Stranger | "middle-upper"<br>Iatan Ls<br>Weston Sh |
| | Lansing | South Bend | Kitaki Ls<br>Gretna Sh<br>Little Kaw Ls |
| | | Rock Lake Sh | *Arbor Hill C* |
| | | Stanton | Stoner Ls<br>Eudora Sh<br>Captain Crk Ls |
| | | Vilas Sh | |
| | | Plattsburg | Spring Hill Ls<br>Hickory Crk Sh<br>Merriam Ls |
| | Kansas City | Lane Sh | Bonner Spgs Sh<br>Farley Ls<br>Island Crk Sh |
| | | Wyandotte | Argentine Ls<br>Quindaro Sh<br>Frisbie Ls |
| | | Liberty Memorial | |
| | | Iola | Raytown Ls<br>Muncie Crk Sh<br>Paola Ls |
| | | Chanute Sh | |
| | | Dewey | Cement City Ls<br>Quivira Sh<br>Pammel Park Ls |
| | | Nellie Bly Sh | *Harmon Tunnel C* |
| | | Cherryvale Sh | Westerville Ls<br>Wea Sh<br>Block Ls<br>Fontana Sh |
| | Bronson | Dennis | Winterset Ls<br>Stark Sh<br>Canville Ls |
| | | Galesburg Sh | *Davis City C* |
| | | Swope | Bethany Falls Ls<br>Hushpuckney Sh<br>Middle Creek Ls |
| | | Elm Branch Sh | |
| | | Hertha | Sniabar Ls<br>Mound City Sh<br>East Peru Ls |
| | | Pleasanton | Shale Hill Sh<br>*Ovid C*<br>Exline Ls<br>Hepler Sh<br>*Grain Vally C* |
| Desmoinesian | Marmaton | Lost Branch | Cooper Crk Ls<br>Nuyaka Crk Sh<br>Sni Mills Ls |

**Figure 2**. Comparison of Missourian Stage (Bronson, Kansas City, Lansing, and Douglas Groups) Stratigraphy used in Iowa historically (Landis and Van Eck, 1965), most recently (Ravn and others (1984)), and new (Pope, 2008).

## KANSAS CITY GROUP

Hinds (1912) referred to the interval from the Hertha Limestone to Argentine Limestone as Kansas City Limestone, but Broadhead (1868) used the term for a limestone that resembled the Kansas City oolite. Hinds and Greene (1915) raised the Kansas City to formational rank, and Moore (1936) raised it to group rank, including all strata between the Fontana and Bonner Springs. It was revised by Moore (1948) and Condra (1949) to include all strata from the base of the Hertha to the top of the Bonner Springs. Moore and others (1951) divided the Kansas City Group into three subgroups, in ascending order: Bronson, Linn, and Zarah, which are still used in Kansas (Heckel and Watney, 2002) and Missouri (Gentile and Thompson, 2004). In Iowa, Ravn and others (1984) raised the Bronson from subgroup to group status, and the Linn and Zarah are not recognized.

The Kansas City Group includes the succession between base of Fontana Shale Member of the Cherryvale Shale to top of Bonner Springs Shale Member of the Lane Shale, and it overlies the Bronson Group and underlies the Lansing Group. It is further divided into eight formations with sixteen members and one bed. The Kansas City Group is about 300 ft (90 m) thick in the type region of Kansas City, and thins to about 100-150 ft (30-45 m) in Iowa. A reference section for the Kansas City Group in Iowa has been designated by Pope (2009) as the 375.8-489.7 foot interval in the Bedford Quarry Hr-65 core (W-30816).

### DEWEY FORMATION
(new name in Iowa, Pope, 2009)

The Dewey Formation was named by Ohern (1910) from exposures near Dewey in the old Dewey Portland Cement Company quarry, section 26, T. 27 N., R. 13 E., Washington County, Oklahoma.

Since 1947, the Dewey and Corbin City limestones have been considered members of the Drum Formation in southeast Kansas. In the Kansas City area, the Cement City Limestone correlated with the Drum, and Quivira Shale was the uppermost member of the Cherryvale Shale. The discovery of the Cement City Limestone Member and underlying Quivira Shale Member above the Drum Limestone in its type area in southeast Kansas led to the problem of what to call ‘Drum’ in the Kansas City area. The discovery of the Quivira Shale at the base of the type Dewey Formation in Oklahoma led its inclusion into the Dewey, below the Cement City Limestone Member. The Westerville Limestone was now the top of the Cherryvale Shale in the Kansas City area and northward, correlating with the Drum Limestone of southeastern Kansas, Watney and others (1989), Heckel (1992) and Heckel and Watney (2002). The Dewey Formation overlies the Nellie Bly Shale and underlies the Chanute Shale. In Iowa, the formation comprises three members in descending order: Cement City Limestone, Quivira Shale, and Pammel Park Limestone (Figure 3).

Pope (2009) designated a reference section in Iowa at exposures in a south-facing cutbank of Middle River, 1.1 miles ( 1.8 km) west of Pammel State Park in the NE-NE-SW section 17, T. 75 N., R. 28 W., Madison County, Iowa.

#### Cement City Limestone Member
#### (reclassified)

Named by Hinds and Greene (1915) for Cement City, Jackson County, Missouri, Moore (1936) located the type section at the Lafarge Corporation quarry (formerly of the Missouri Portland Cement Company Sugar Creek plant), SE section 14, SW-SW section 13 and NE section 23, T. 50 N., R. 32 W. It overlies the Quivira Shale Member and underlies the Chanute Shale.

**Figure 3**. Overview of Dewey Formation, Nelly Bly Shale, and Cherryvale Shale at Thayer Quarry, Union County. The Cement City Member of Dewey Formation is visible as uppermost light-colored limestone in picture (just below drain pipe) and Quivira Shale Member as dark band just below Cement City. Pammel Park Limestone Member absent at Thayer. Nelly Bly is thin light-colored shale between Westerville and Quivira. The Westerville Limestone Member of the Cherryvale Shale is second light-colored limestone from top of high wall. The Wea Shale Member is thick dark gray shale in middle of picture. The Block Limestone Member is "double" limestone below base of Wea. The Fontana Shale Member is dark-colored shale underlain by light-colored shale between the Block and Winterset. The top of the Winterset Limestone Member of the Dennis Formation is visible above and along bottom edge of photograph.

The Cement City correlates with the Flat Creek Limestone of Illinois, the Cambridge-Nadine limestones of the Appalachian Basin and the Mid-Posideon Limestone of Texas.

Pope (2009) designated a reference section at exposures in a south-facing cutbank of Middle River, 1.1 miles ( 1.8 km) west of Pammel State Park in the NE-NE-SW section 17, T. 75 N., R. 28 W., Madison County, Iowa.

## Quivira Shale Member
## (new name in Iowa, Pope, 2009)

The Quivira Shale Member was named by Moore (1931, 1932) and defined by Newell (1935). Moore (1936) located the type section at exposures near Quivira Lake, section 32, T. 11 S., R. 24 E., Johnson County, Kansas. In Iowa, the Quivira Shale Member overlies the Pammel Park Limestone Member (or Nellie Bly Shale if Pammel Park Limestone is absent) and underlies the Cement City Limestone Member.

Pope (2009) designated a reference section in Iowa at exposures in a south-facing cutbank of Middle River, 1.1 miles ( 1.8 km) west of Pammel State Park in the NE-NE-SW section 17, T. 75 N., R. 28 W., Madison County, Iowa.

### Pammel Park Limestone Member
### (new name in Iowa, Pope, 2009)

The Pammel Park Limestone was named by Heckel and Pope (1992) for exposures in a south-facing cutbank of Middle River, 1.1 miles (1.8 km) west of Pammel State Park, NE-NE-SW section 17, T. 75 N., R. 28 W., Madison County, Iowa. Pammel Park was named after Louis Pammel, botany professor at Iowa State College, Ames. Outside of Pammel State Park, the limestone is present in several outcrops and cores in Iowa and Missouri but rarely occurs as lenticular limestone in outcrops in Kansas. In Iowa, the Pammel Park Limestone Member, where present, overlies the Nellie Bly Shale and underlies the Quivira Shale Member. While the Pammel Park Limestone Member is absent in Thayer Quarry, an equivalent gray fossiliferous shale is present above the Harmon Tunnel Coal.

Pope (2009) designated a reference section in Iowa at exposures in a west-facing cutbank of Tom Creek, in the SW-NW-SW section 30, T. 77 N., R. 28 W., Madison County, Iowa.

## NELLIE BLY SHALE
## (new name in Iowa, Pope, 2009)

Gould (1925), from an unpublished 1914 manuscript by Ohern, applied the term 'Nellie Bly' to shale and sandstone above the Hogshooter (Dennis) Formation and below the Dewey Formation. Oakes (1940) designated the type area for exposures along Nellie Bly Creek in sections 28, 29, 31, 32, T. 24 N., R 13 E., southwest of Ramona, Washington County, Oklahoma. The Nellie Bly Shale overlies the Cherryvale Shale and underlies the Dewey Formation. Where the Pammel Park Limestone Member is absent, the top of the Nellie Bly Shale is at the top of the Harmon Tunnel Coal bed (or its horizon) at the base of the dark shale facies of the Quivira Shale Member of the Dewey Formation.

A reference section in Iowa was designated by Pope (2009) at exposures in a south-facing cutbank of Middle River, 1.1 miles ( 1.8 km) west of Pammel State Park in the NE-NE-SW section 17, T. 75 N., R. 28 W., Madison County, Iowa.

### *Harmon Tunnel Coal bed*
### (Pope, 2009)

The Harmon Tunnel Coal bed was named by Pope (2009) for exposures in a south-facing cutbank of Middle River, 1.1 miles ( 1.8 km) west of Pammel State Park in the NE-NE-SW section 17, T. 75 N., R. 28 W., Madison County, Iowa. It was named from the Harmon Tunnel, the only highway tunnel in the state of Iowa, located in Pammel State Park. The Harmon Tunnel was dug in 1858 by William Harmon to supply water to a sawmill and grist mill. At its type locality, the coal is 2 inches (5 cm) thick and overlies a thick, blocky, light to greenish gray mottled with moderate red mudstone paleosol.

Pope (2009) designated a reference section at exposures in a west-facing cutbank of Tom Creek, in the SW-NW-SW section 30, T. 77 N., R. 28 W., Madison County, Iowa.

## CHERRYVALE SHALE
## (revised by Pope, 2009)

The Cherryvale Shale was named by Haworth (1898) for exposures in the bluffs around Cherryvale Kansas. Moore (1948, 1949b) defined the subdivisions and refined the usage of the name. Heckel and Watney (2002) located the type section 2 miles (3 km) north of the town of Cherryvale, in the bed of Cherry Creek, just south of the road intersection along the E line of SE-SE-SE section 32, T. 31 S., R. 17 E., Montgomery County, Kansas.

The formation comprises four members in descending order: Westerville Limestone, Wea Shale, Block Limestone, and Fontana Shale (Figure 3). Prior to Watney and others (1989), the Cherryvale also contained the Quivira Shale which was later placed into the overlying Dewey Formation. The Cherryvale Shale overlies the Dennis Formation and underlies the Nellie Bly Shale.

Pope (2009) designated a reference section in Iowa at exposures in a south-facing cutbank of Middle River, 1.1 miles ( 1.8 km) west of Pammel State Park in the NE-NE-SW section 17, T. 75 N., R. 28 W., Madison County, Iowa.

## Westerville Limestone Member

Near DeKalb, Decatur County, Iowa, Bain (1898) used the name DeKalb Limestone to replace the name Fusulina limestone. The Westerville Limestone Member was named by Bain (1898) for exposures on Sand Creek near the town of Westerville [T. 70 N., R. 27 W.], Decatur County, Iowa, and he placed the Westerville 'some little distance above the DeKalb limestone.' Moore and Condra (1932) dropped the name DeKalb in favor of Westerville, and Condra (1933) thought the DeKalb was equivalent to the Winterset Limestone. Moore (1948, 1949b) placed the Westerville within the Cherryvale.

Historically, there has been miscorrelation between the Westerville and the Corbin City and Dewey or Cement City, once members of the Drum Limestone in Kansas. Recently, the Westerville has been correlated to the Drum Limestone of southeast Kansas (Heckel and Watney, 2002), although the Westerville is currently not known in Miami County, Kansas or southward and Drum north of southern Neosho County, Kansas. As a side note, Condra and Upp (1933) traced the so-called Drum Limestone at Kansas City to Winterset, Iowa, where they correlated it with the type Westerville.

The Westerville Limestone Member overlies the Wea Shale Member and underlies the Nellie Bly Shale.

Pope (2009) designated a reference section in Iowa at exposures in a south-facing cutbank of Middle River, 1.1 miles ( 1.8 km) west of Pammel State Park in the NE-NE-SW section 17, T. 75 N., R. 28 W., Madison County, Iowa.

## Wea Shale Member

Named by Moore (1932) and defined by Newell (1935), its type section was located by Moore (1936) near Wea Creek, C east side section 12, T. 18 S., R. 22 E., Miami County, Kansas. Later, Moore (1948, 1949b) applied the name to the shale between the Block and Westerville limestones. The Wea Shale Member overlies the Block Limestone Member and underlies the Westerville Limestone Member. In Madison County, there are several thin argillaceous limestone stringers within the Wea Shale, and we will readily see them at Thayer Quarry.

A reference section in Iowa is designated by Pope (2009) at exposures in a south-facing cutbank of Middle River, 1.1 miles ( 1.8 km) west of Pammel State Park in the NE-NE-SW section 17, T. 75 N., R. 28 W., Madison County, Iowa.

## Block Limestone Member

The Block Limestone Member was named by Moore (1932), and defined by Newell (1935). Moore (1936, 1948) identified roadcuts near the town of Block, Miami County, Kansas as the type section. In Madison County at the Cherryvale Shale reference section, the Block is two layers of lime wackestone, but the upper bed is locally a *Linoproductus* packstone.

At Thayer Quarry, the Block appears as a double limestone in the highwall from a distance, but it is really a series of three limestones (Figure 4). The Block Limestone Member overlies the Fontana Shale Member and underlies the Wea Shale Member. The Block Limestone correlates with the Lower Posideon of Texas.

Pope (2009) designated a reference section in Iowa at exposures in a south-facing cutbank of Middle River, 1.1 miles ( 1.8 km) west of Pammel State Park in the NE-NE-SW section 17, T. 75 N., R. 28 W., Madison County, Iowa.

**Figure 4.** Block Limestone (sticking out from cliff face) at Thayer Quarry.

## Fontana Shale Member

The Fontana Shale Member was named by Moore (1932) and defined by Newell (1935). Moore (1936) located the type section at exposures near the town of Fontana in the NE corner of section 11, T. 18 S., R. 23 E., and near the middle of west side of NW section 36, T. 18 S., R. 23 E., Miami County, Kansas. A thin coal occurs above a blocky mudstone, near the top of the Fontana Shale around Kansas City (Howe, 1986; Thompson, 1995, 2001; Heckel et al., 2003), but has not been observed in Iowa. The Fontana Shale Member overlies the Winterset Limestone Member of the Dennis Formation and underlies the Block Limestone Member.

In Decatur County the lower part is about 4 ft (1.2 m) of medium-gray blocky mudstone overlain by 7 feet (2.1 m) of light gray shale. A zone of abundant *Derbyia* brachiopods occurs at the base of the shale. In the Thayer Quarry, the Fontana is about 3 to 4 ft (0.9 to 1.2 m) of light to greenish gray mudstone with calcareous nodules in the lower part.

Pope (2009) designated a reference section in Iowa at exposures in a south-facing cutbank of Middle River, 1.1 miles ( 1.8 km) west of Pammel State Park in the NE-NE-SW section 17, T. 75 N., R. 28 W., Madison County, Iowa.

## BRONSON GROUP

Haworth (1895) referred to a ‘Triple System’ consisting of the Hertha, Bethany, and Winterset Limestones. Adams (1904) named the Bronson and noted that it comprised in ascending order: Hertha Limestone, Galesburg Shale, Dennis Limestone, Cherryvale Shale, and Drum Limestone, equivalent to Haworth’s ‘Triple System’. Moore (1932) revised the Bronson to include strata from the Critzer Limestone to the Dennis Limestone and further redefined it as comprising the: Hertha Limestone, Ladore (Elm Branch) Shale, Swope Limestone, Galesburg Shale, and Dennis Limestone (Moore, 1948). Heckel and Pope (1992), Heckel and others (1999) and Heckel and Watney (2002) realized the Ladore Shale was miscorrelated and placed it higher in the succession, overlying the Bethany Falls Member of the Swope Formation and underlying the Mound Valley Limestone in southern Kansas. They renamed the shale above the Hertha Formation and below the Swope Formation, the Elm Branch Shale, where the Mound Valley is not present.

Moore (1936) raised the Kansas City to group status, including all strata from the Fontana Shale to Bonner Springs Shale, and later revisions lowered the base of the Kansas City Group to the base of the Hertha Limestone. In Iowa, Ravn and others (1984) used Moore’s 1936 definition of the Kansas City Group to raise the Bronson from subgroup to group status (Figure 2). This made the Bronson Group the lowermost major division of the Missourian and reduced the Pleasanton to formational rank within the Bronson. The Bronson Group in Iowa includes in descending order: Dennis, Galesburg, Swope, Elm Branch, Hertha, and Pleasanton. The type locality of the Bronson Group is in the vicinity of Bronson, Bourbon County, Kansas. The Bronson Group is about 100-130 ft (30-40 m) thick in southwest Iowa (Witzke et al., 2003a).

The 984.8-1084.0 foot interval in the GSB SW-4 Riverton core (W-27556) and the 489.6-585.5 foot interval in the Bedford core were designated by Pope (2009) as reference sections in Iowa. The interval from the top of the Winterset Limestone to the top of the Exline Limestone occurs in the Crescent quarry, Pottawattamie County.

## DENNIS FORMATION

The Dennis Formation was named by Adams (1903) and defined by Jewett (1932). Moore (1936) described typical exposures near the town of Dennis in the northwest corner of section 14, T. 31 S., R. 18 E., Labette County, Kansas. The formation overlies the Galesburg Shale and underlies the Cherryvale Shale. The formation comprises three members: the Winterset Limestone, Stark Shale, and Canville Limestone, in descending order (Figure 5).

Pope (2009) designated a reference section for Iowa at exposures in a south-facing cutbank of Middle River, 1.1 miles ( 1.8 km) west of Pammel State Park in the NE-NE-SW section 17, T. 75 N., R. 28 W., Madison County, Iowa.

**Figure 5.** Profile of Dennis Formation and Cherryvale Shale at Thayer Quarry. Winterset Limestone (light-colored limestone) and Stark Shale members visible, Canville Limestone absent. Note shale parting within Winterset Limestone.

## Winterset Limestone Member

The Winterset Limestone Member was named by Tilton and Bain (1897), and Moore (1936) and Baars and Maples (1998) located the type locality of the Winterset in the vicinity of Winterset, Madison County, Iowa, section 22, T. 75 N., R. 28 W. Thompson and others (1956) described and located the Winterset Limestone at its type section. Felton and Heckel (1996) described several cycles of deposition within the Winterset Limestone they termed 'phased regression,' relating them to glacio-eustatic sea level changes.

**Figure 6.** Exposure of Galesburg Shale to lower Cherryvale Shale at Thayer Quarry. Winterset Limestone (middle of picture) and underlying Stark Shale (lower dark band) can be clearly seen in high wall. The Winterset is one of the major limestones quarried at Thayer. John Pope for scale. Photo by Brian Witzke.

The Winterset Limestone, extensively quarried at the Crescent, Thayer (Figure 6), Osceola, Earlham, Winterset, Decatur County, Jefferson (north of Greenfield) quarries, overlies the Stark Shale Member and underlies the Fontana Shale Member of the Cherryvale Shale. It correlates with the Carthage (Shoal Creek) Limestone of the Illinois Basin, and the upper Brush Creek-Pine Creek limestones of the Appalachian Basin.

Pope (2009) designated a reference section at exposures in a south-facing cutbank of Middle River, 1.1 miles ( 1.8 km) west of Pammel State Park in the NE-NE-SW section 17, T. 75 N., R. 28 W., Madison County, Iowa.

## Stark Shale Member

Hinds and Greene (1915), Moore and Haynes (1917), McCourt (1917), Moore (1920), and Condra (1927) included what is now the Stark Shale and underlying Canville Limestone as the upper part of the Galesburg Shale Member of the Kansas City Formation. Jewett (1932) named the Stark Shale Member from the town of Stark, Neosho County, Kansas. Moore (1936) described typical exposures near the type area, and Heckel and Watney (2002) designated a principal reference section in a roadcut along the S line SW-SE-SW section 13, T. 27 S., R. 20 E., Neosho County, Kansas. The Stark Shale Member overlies the Canville Limestone Member (or the Galesburg Shale where the Canville is absent) and underlies the Winterset Limestone Member.

Pope (2009) designated a reference section at exposures in a south-facing cutbank of Middle River, 1.1 miles ( 1.8 km) west of Pammel State Park in the NE-NE-SW section 17, T. 75 N., R. 28 W., Madison County, Iowa.

## Canville Limestone Member

The Canville Limestone Member was named by Jewett (1932) for exposures along Canville Creek, and Moore (1936) described exposures in roadcuts about 3 miles (4.8 km) west of Stark, Neosho County, Kansas. Heckel and Watney (2002) located a principal reference section in the S line SW-SE-SW section 13, T. 27 S., R. 20 E. The Canville Limestone Member overlies the Galesburg Shale and underlies the Stark Shale Member. Typically, the Canville consists of less than 1 foot (30 cm) of medium to dark-gray skeletal lime wackestone. In south-central Iowa, it is lenticular and discontinuous with lenses from a few inches (cm), in Madison County, to over 40 ft (64 m) across, in Adair County. It is absent at Thayer Quarry although nearby lenses of limestone may be Canville.

Pope (2009) designated a reference section at exposures in a south-facing cutbank of Middle River, 1.1 miles ( 1.8 km) west of Pammel State Park in the NE-NE-SW section 17, T. 75 N., R. 28 W., Madison County, Iowa.

## GALESBURG SHALE
(new bed recognized by Pope, 2009)

The Galesburg shale was originally named by Adams (1903), and Moore (1936) described a type section north of the town of Galesburg, Neosho County, Kansas. In Iowa, the Galesburg Shale overlies the Swope Formation and underlies the Dennis Formation. In southern Kansas, the Ladore Shale overlies the Swope Formation and underlies the Mound Valley Limestone, which is overlain by Galesburg Shale. Where the Canville Limestone Member of the Dennis is not present, the top of the Galesburg Shale is at the top of the Davis City Coal bed (or its horizon) at the base of the dark fissile shale facies of the Stark Shale Member of the Dennis Formation. Pope (2009) noted in Iowa it contains a single recognized bed, the Davis City Coal, at or near its top.

The Galesburg is usually 6-10 ft (1.8-3 m) of light to greenish gray blocky mudstone with irregularly shaped carbonate concretions in the basal part which may be reworked underlying Bethany Falls Limestone.

A reference section is designated at exposures in a south-facing cutbank of Middle River, 1.1 miles ( 1.8 km) west of Pammel State Park in the NE-NE-SW section 17, T. 75 N., R. 28 W., Madison County, Iowa.

### *Davis City Coal bed*
### (new name in Iowa, Pope, 2009)

The Davis City Coal bed was named by Schutter and Heckel (1985) for exposures in a quarry 2 miles (3.2 km) west of Davis City in SE NE section 4, T. 67 N., R. 26 W., Decatur County, Iowa. There is often an ostracodes-rich zone associated with the coal. A few meters downstream from the quarry, glacial striations can be seen on the higher Winterset Limestone.

In Madison and Clarke counties the Davis City Coal varies in thickness from a smut to 1.5 inches (3.81 cm). In the Thayer Quarry, a zone of compressed *Calamites* with spirorbid worm tubes, inarticulate brachiopods, and pecten-like pelecypods, up to 2 ft (60 cm) thick, occurs just above the coal.

Pope (2009) designated a reference at exposures in a south-facing roadcut along County Road P-71 at the south edge of Winterset, in the NW-SW-NW section 6, T. 75 N., R. 27 W., Madison County, Iowa.

## SWOPE FORMATION

The name Swope Formation was originally used by Moore (1932) and was defined as it is presently used by Newell (1935) for exposures in Swope Park in Kansas City, Missouri. The Swope Formation overlies the Elm Branch Shale and underlies the Galesburg Shale. In Iowa, the formation comprises three members in descending order: Bethany Falls Limestone, Hushpuckney Shale, and Middle Creek Limestone (Figure 7).

A reference section in Iowa is designated by Pope (2009) at exposures in a south-facing roadcut along County Road P-71 at the south edge of Winterset, in the NW-SW-NW section 6, T. 75 N., R. 27 W., Madison County, Iowa.

**Figure 7**. Overview of Dennis, Galesburg, and upper Swope formations at Decatur City Quarry. Winterset Member of Dennis is visible as upper tan limestone in high wall and Stark Member as dark band in middle of photo. Galesburg is thick light-colored shale, and Bethany Falls (Swope Formation) is lower limestone bed.

## Bethany Falls Limestone Member

Called 'the great limestone at Winterset' by Keyes (1896), Bain (1896) and local quarrymen referred to it as 'Earlham Limestone' for quarry exposures east and southeast of Earlham, Madison County. Bain's (1896) name 'Earlham' was dropped because the name Bethany Falls Limestone (called Bethany Limestone by some early workers) had been first given to that limestone by Broadhead (1862). Originally, the Bethany Falls was defined to include everything from Hertha to Dennis, now the Bronson Subgroup of Kansas and Missouri nomenclature (Keyes, 1896, Bain 1898, and Haworth, 1898). In Iowa, this included the Fragmental, Earlham and Winterset limestones. The Bethany Falls had also been miscorrelated to the lower Hertha Limestone (Bain, 1898, and Tilton and Greene, 1914). Newell (1935) redefined the Bethany as the upper member of the Swope Formation as it is used today. A type section later described by Moore (1936) was located on the Falls on Big Creek at Bethany, Harrison County, Missouri, SW-SW-NE-SE section 9, T. 63 N., R. 28 W., at the west edge of Bethany (Gentile and Thompson, 2004).

The Bethany Falls Limestone Member overlies the Hushpuckney Shale Member and underlies the Galesburg Shale and is about 22 feet (6.7 m) thick in Madison County. Because of its thickness, it is considered an economic limestone for aggregate material, quarried at Thayer, Logan and Crescent quarries in Pottawattamie County, Jefferson Quarry in Adair County, and Atlantic Quarry in Cass County. Pope (1993, 1994, 1995) traced minor cycles in the Bethany Falls Limestone from Winterset, Iowa to Kansas City, Missouri. Phylloid algae is present in the lower part of the Bethany Falls exposure at Decatur City Quarry which can be readily seen in spoil piles (Figure 8).

The Bethany Falls Limestone correlates with the Macoupin Limestone of Illinois, the Upper Salesville Limestone of Texas, and the lower Brush Creek limestone of the Appalachian Basin.

**Figure 8**. Close-up of phylloid algae in Bethany Falls Limestone at Decatur City Quarry, quarter for scale. Dark gray chert nodule can be seen in lower right hand corner. Photo by Brian Witzke.

Pope (2009) designated a reference section in Iowa at exposures in a south-facing roadcut along County Road P-71 at the south edge of Winterset, in the NW-SW-NW section 6, T. 75 N., R. 27 W., Madison County, Iowa.

### Hushpuckney Shale Member

The name Hushpuckney Shale Member was originally used by Newell, unpublished manuscript, and formally named by Jewett (1932). Newell (1935) defined it and established the type section on Hushpuckney Creek about 2 miles (3.2 km) southwest of Fontana, Miami County, Kansas. Moore (1936) located a type section for exposures on Hushpuckney Creek, and noted it was typically exposed in a railroad cut in the C N line section 22, T. 18 S., R. 24 E., Miami County, Kansas (see Thompson, 2001; Gentile and Thompson, 2004). Baars and Maples (1998) believed it was typically exposed in a railway cut in the C N side section 13, T. 19 S., R 23 E. The latter location is correct. The Hushpuckney Shale Member overlies the Middle Creek Limestone Member and underlies the Bethany Falls Limestone Member. The Hushpuckney normally consists of 3-4 ft (0.9-1.2 m) of dark gray to black fissile shale in its lower part and medium gray shale in its upper part in Madison County.

A reference section in Iowa was designated by Pope (2009) at exposures in a south-facing roadcut along County Road P-71 at the south edge of Winterset, NW-SW-NW section 6, T. 75 N., R. 27 W., Madison County, Iowa.

### Middle Creek Limestone Member

The name Middle Creek Limestone was originally used by Newell (in Jewett 1932) and later defined by Newell (1935). Moore (1936) located the type section on Middle Creek at the main highway crossing, 3 miles (4.8 km) east of La Cygne, SW section 22, T. 18 S., R. 24 E (see Baars and Maples, 1998; Thompson, 2001). Heckel and Watney (2002) located the type section east of Middle Creek, west of the SE corner section 36, T 19 S., R 24 E., Linn County, Kansas. The latter location is the same one given by Newell (1935) and correct. The Middle Creek Limestone Member overlies the Elm Branch Shale and underlies the Hushpuckney Shale Member. In Madison County it usually consists of a single bed of lime wackestone 3-6 inches (7.5-15 cm) thick, but may be two limestone beds separated by a thin shale parting.

Pope (2009) designated a reference section in Iowa at exposures in a south-facing roadcut along County Road P-71 at the south edge of Winterset, in the NW-SW-NW section 6, T. 75 N., R. 27 W., Madison County, Iowa.

## ELM BRANCH SHALE
(new name in Iowa, Pope, 2009)

The name Elm Branch Shale was originally to be proposed by Newell (in Moore, 1932), but was never formally adopted due to miscorrelation with the Ladore Shale and miscorrelation of overlying Bethany Falls Limestone with Mound Valley Limestone, in Kansas. Since then, the miscorrelations have been corrected, so Heckel (1992), Heckel and Pope (1992), Watney and Heckel (1994) and Heckel and Watney (2002) revived the unused name for the shale between the Swope and Hertha formations. The Elm Branch ranges from 1 ft (30 cm) in the Crescent Quarry (Harrison County) to about 26 ft (8 m) east of Peru (Madison County). The Elm Branch overlies the Hertha Formation and underlies the Swope Formation.

## HERTHA FORMATION

The Hertha Formation was derived from the Hertha limestone of Adams (1903). The name was derived from exposures around the former town of Hertha, Neosho County, Kansas. Newell (1935) concluded the limestone there which Adams in 1903 applied the name Hertha is actually the Bethany Falls Limestone of the overlying Swope Formation. The Hertha Formation overlies the Pleasanton Formation and underlies the Elm Branch Shale. In Iowa, the Hertha Formation comprises three members, in ascending order: East Peru Limestone, Mound City Shale, and Sniabar Limestone. Pope (2009) designated reference sections for the Hertha Formation in Iowa at an outcrop of the Sniabar Limestone with a 'middle shale facies' in a south-facing backslope cutbank on a private road to the waste water treatment plant south of Winterset, SW-NE-SW section 5, T. 75 N., R. 27 W., and without the 'middle shale facies,' in a west-facing cutbank exposures in a tributary to Clanton Creek, NE-SW-NE section 12, T. 74 N., R. 27 W., Madison County, Iowa.

## PLEASANTON SHALE

The name Pleasanton was first used by Haworth (1895) for rocks between the upper Pawnee limestone (Coal City) and the base of the overlying Hertha limestone exposed near Pleasanton, Linn County, Kansas. In Kansas, Moore (1932) and in Nebraska, Condra (1935) dropped the name and used the name Bourbon Group. McQueen and Greene (1938) excluded all Desmoinesian strata from the Pleasanton, and Moore (1948) dropped the name Bourbon in favor of Pleasanton. Since there are only three major units and two named coal beds in Iowa, Pope (2009) proposed, as did Ravn and others (1984), that Pleasanton be reduced to formational rank in Iowa becoming the basal part of the Bronson Group and the three major units recognized as members.

The 1063-1084 foot interval in the Riverton core, the 63.0-84.9 foot interval in the Logan core and the 51.4-72.6 foot interval in CP-37 are designated as reference sections in Iowa by Pope (2009). Pope (2009) also designated a reference section in Iowa in a south-facing backslope cutbank on a private road to the waste water treatment plant south of Winterset, SW-NE-SW section 5, T. 75 N., R. 27 W., Madison County.

## STRATIGRAPHY OF DECATUR CITY QUARRY

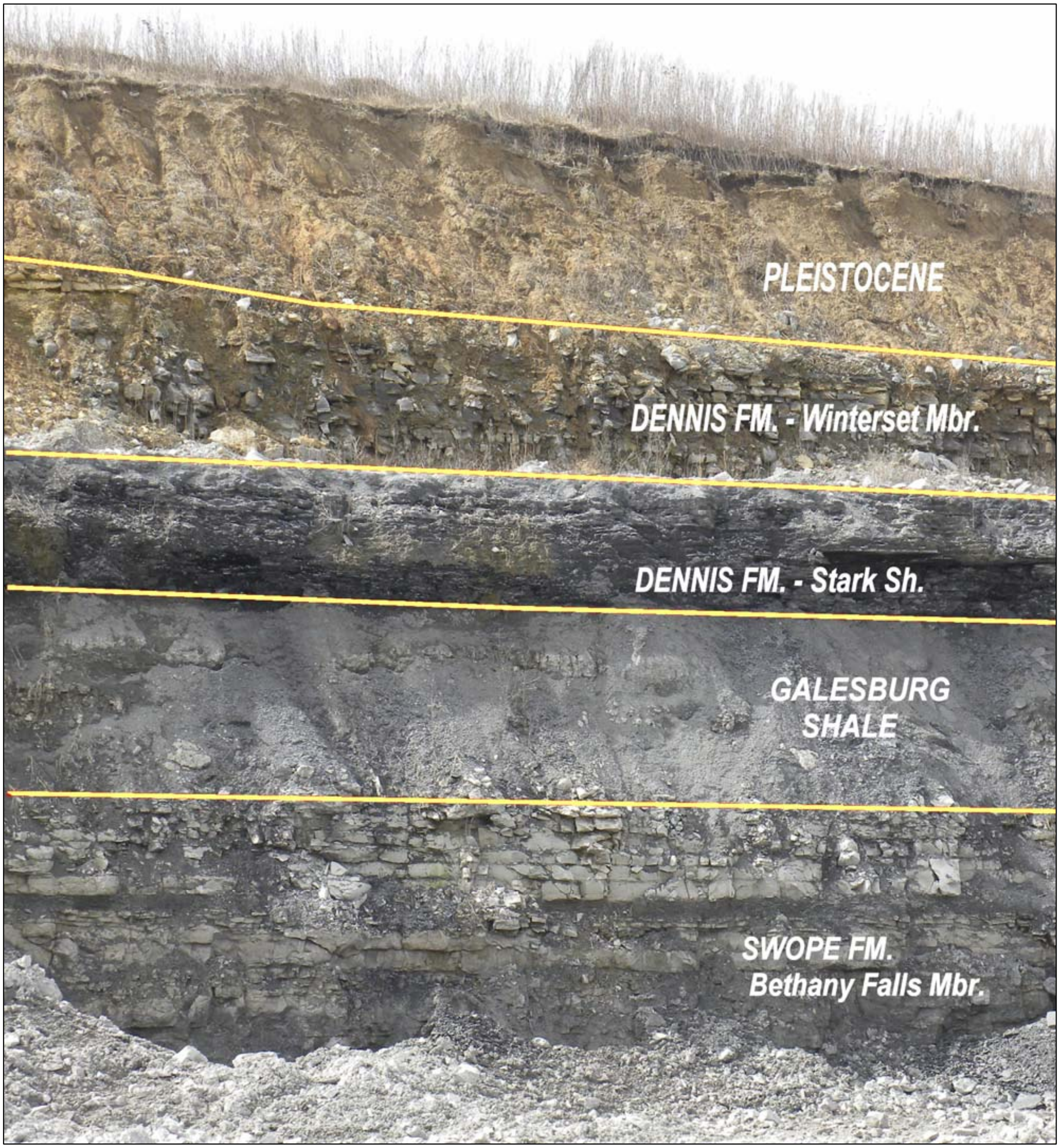


**Figure 9.** Pennsylvanian succession exposed along the south high wall at Decatur City Quarry, Decatur County. The annotated photo above displays the stratigraphy at the quarry, with formation names labeled in uppercase and member names labeled in title case. Photo and annotation by Brian Witzke.

The succession in the Decatur Quarry ranges from the upper part of the Bethany Falls Member of the Swope Formation to the Winterset Limestone Member of the Dennis Formation of the Bronson Group.

Composite of measured section on eastern and northern highwalls and of core (18-07) drilled at quarry (40.73136°N 93.8725°W, surface elevation 982.14 ft), Decatur County, Iowa
Measured with Charles Monson, March 15, 2010, and Jason Vogelgesang, April 1, 2010

PENNSYLVANIAN SUBSYSTEM
MISSOURIAN SERIES
BRONSON GROUP

DENNIS FORMATION

**Winterset Limestone Member**

20. Limestone, blocky; light gray with orangish-brown rind, fusulinid packstone, very thin shale layer 2 feet above lower contact, silty, reddish tan fusulinids which are concentrated in some areas while sparse in others, productids, small brachiopods, fossil hash…………………………………………………………………….…3 ft (0.90 m)

19. Shale, clayey; orangish-brown, weathered, blocky beds, very fossiliferous, very small crinoid discs and unidentified shell fragments, fossils are concentrated toward top of shale and may be weathering out of overlying limestone……………...…1.5 ft (0.45 m)

18. Limestone; light gray with orangish-brown rind…………………......0.4 ft (0.12 m)

17. Shale, clayey; orangish-brown, weathered…………………………....0.5 ft (0.15 m)

16. Limestone, blocky; light gray with orangish-brown rind, mudstone to wackestone, large productid brachiopods……………………………………………....1.5 ft (0.45 m)

15. Shale, clayey; orangish-brown…………………………………….….0.1 ft (0.03 m)

14. Limestone, blocky; light gray with orangish-brown rind, mudstone to wackestone, medium-bedded (0.3- to 1.0-foot beds), fractured, medium to dark gray chert nodules, fossiliferous……………………………………………………………6.0 ft (1.8 m)

**Stark Shale Member**

13. Shale, black, fissile; Grayish black to dark gray, finely micaceous, slightly calcareous, moderately interlaminated with dark gray laminae in upper part, lowermost 2 inches brachiopod-rich and calcareous………………………………..……...2.2 ft (0.7 m)

GALESBURG SHALE

12. Shale; Light to medium gray clayey shale interlaminated with light gray silt, wavy laminae, calcareous, 0.5-cm diameter oval nodules, brachiopods, pelecypods, *Calamites,* spirorbid worm tubes near base… …………..4.2 ft (1.7 m)

11. **Davis City Coal bed**……………………………………...….0.5 in (1.3 cm)

10. Mudstone, paleosol; Greenish-gray to light gray, blocky, slickensided, pyritic, calcareous nodules at base, irregular contact with underlying unit……7.3 ft (2.2 m)

<u>SWOPE FORMATION</u>

**Bethany Falls Limestone Member**

9. Limestone, argillaceous lime mudstone; Very light brownish-gray with medium gray mottles, wavy laminations (possibly tidal flat laminations), calcareous concretions, heavily karsted, greenish-gray clay filled tubes (possibly solution-enlarged root molds), slickensided, possibly pedogenized, Pectenoid and myalinid clams, irregular contact with overlying unit……………………………………...…………..…7.2 ft (2.2 m)

8. Limestone; Very light gray to greenish-gray, lime wackestone to packstone, massive, argillaceous, dark gray chert nodules about 1.0-2.0 feet (0.3-0.6 m) below upper contact…………..………………………………...…………………...2.0 to 3.0 ft (0.6 to 0.9 m)

7. Shale, clayey, fissile; Greenish-gray, brachiopods and crinoids.......0.5 ft (0.15 m)

6. Shale, clayey, fissile; Grayish-black, irregular calcareous lenses and nodules, brachiopods and crinoids…………………………………………...0.3 ft (0.09 m)

5. Shale, clayey, fissile; Greenish-gray, bryozoa, brachiopods and crinoids…………………………………………………………......0.1 ft (0.03 m)

4. Limestone; Brownish-gray, wackestone to packstone, wavy-bedded, argillaceous, fossiliferous, phylloid algae from lower contact to 2.0 ft (0.6 m) above lower contact, brachiopods, wavy contact with underlying shale……………………2.4 ft (0.7 m)

3. Shale, clayey, blocky; Dark greenish-gray to light gray, pyrite, irregular calcareous lenses and nodules, wavy contact with overlying limestone……....…0.2 ft (0.06 m)

2. Limestone; Brownish-gray, lime wackestone to packstone, flat-bedded, crystalline, hard, conchoidal fracture, calcite and dolomite rhombs, pyrite clusters, dark gray to light bluish gray chert nodules in upper 2.0 ft (0.6 m), greenish-gray shaly laminae; fossiliferous: fusulinids, bryozoa, brachiopods and crinoids, small pyritized brachiopods near lower part, lower contact of unit not exposed………………..….4.8 ft (1.4 m)

**Hushpuckney Shale Member**

1. Shale, black, fissile; Grayish black, pyritic with thin laminae and nodules, lower 8 inches carbonaceous, inarticulate brachiopods in upper part…………2.4 ft (0.7 m)

## STRATIGRAPHY OF THAYER QUARRY

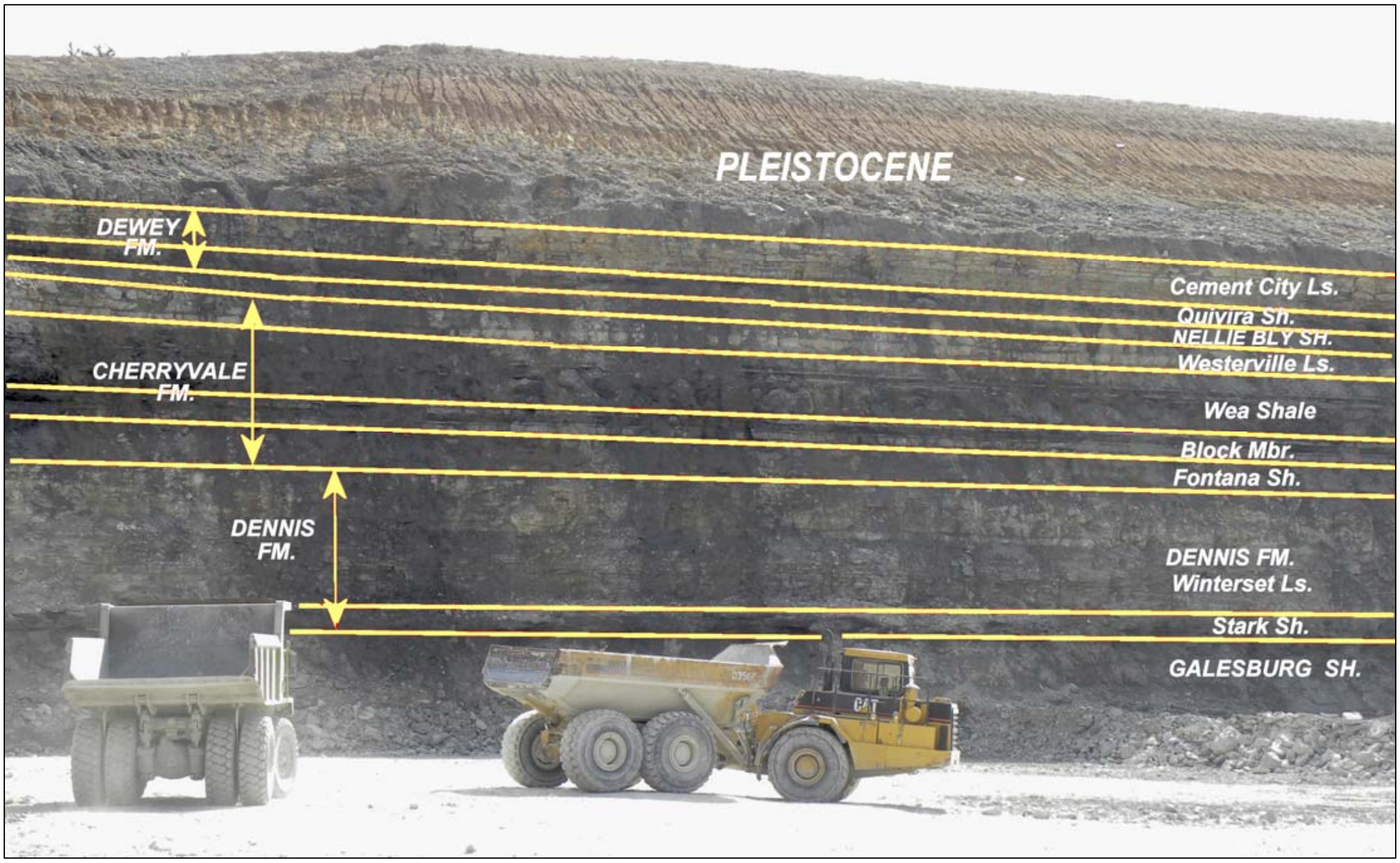


**Figure 10.** Annotated photo illustrating the Pennsylvanian stratigraphy along the south high wall at Thayer Quarry, Union County. Formation names labeled in uppercase and member names labeled in title case. Prominent units include the Winterset Limestone, Block Limestone, Wea Shale, Westerville Limestone, and Cement City Limestone. The Galesburg Shale, while present, is heavily slumped and mostly covered. The Stark, Fontana, Nellie Bly, and Quivira shales can be seen on highwall but are not prominent. Absent units include Canville and Pammel Park limestones. A more spectacular exposure can be seen on the west high wall. Photo and annotation by Brian Witzke.

The succession in the Thayer Quarry ranges from top of the Bethany Falls Member of the Swope Formation of the Bronson Group to the Cement City Member of the Dewey Formation of the Kansas City Group.

Composite section from descriptions by John Pope in NW-SW-NE Sec. 35, T72N, R28W, and Greg Schildberg in NW-SE Sec 35, T72N, R28W, surface elevation 1034.9 feet, Union County, Iowa

PENNSYLVANIAN SUBSYSTEM
MISSOURIAN SERIES
KANSAS CITY GROUP

DEWEY FORMATION

**Cement City Limestone Member**

24. Limestone; Light gray, lower part packstone to grainstone, upper part grainstone, calcite spar………………………………………………………..…2.0 ft (0.6 m)

23. Limestone, argillaceous, nodular…………......………………...…2.0 to 3.0 ft (0.6 to 0.9 m)

22. Limestone; Light gray, wackestone, wavy-bedded……….........4.0 ft (1.2 m)

21. Limestone, argillaceous, shaly…………………………………....0.8 ft (0.24 m)

**Quivira Shale Member**

20. Shale, calcareous; Greenish-gray, scattered limestone nodules..2.7 ft (0.81 m)

19. Shale, black, fissile……………………………………………..1.2 ft (0.36 m)

**Pammel Park Limestone equivalent**

18. Shale; Light gray, fossiliferous…………………………………0.8 ft (0.24 m)

NELLIE BLY SHALE

17. **Harmon Tunnel Coal bed**……………………………………..0.25 to 0.5 in (0.6 to 1.3 cm)

CHERRYVALE SHALE

**Westerville Limestone Member**

16. Limestone; Greenish-gray, wackestone at base becoming packstone at top, massive, blocky, fine calcite crystals, algal, greenish shale laminations…..…2.8 ft (0.84 m)

15. Shale, calcareous; Light gray to greenish gray…………………..0.5 ft (0.15 m)

14. Limestone; Tan, wackestone, massive…………………………..1.3 ft (0.4 m)

**Wea Shale Member**

13. Shale; Medium to dark gray, fossiliferous………………………4.0 ft (1.2 m)

12. Shale; Dark gray, four to five bluish gray carbonate stringers; fossiliferous: brachiopods, fenestrate bryozoans, crinoids, gastropods, pelecypods, filled burrows………………………………………………………...9.0 ft (2.7 m)

**Block Limestone Member**

11. Limestone; Blue-gray, series of three limestones separated by shales, lower two limestones packstones, upper limestone wackestone…………..…….2.0 ft (0.6 m)

**Fontana Shale Member**

10. Mudstone, paleosol; Medium/light gray to greenish gray, calcareous nodules in lower part ……………………………………………………….…3.0 to 4.0 ft (0.9 to 1.2 m)

## BRONSON GROUP

<u>DENNIS FORMATION</u>

**Winterset Limestone Member**

9. Limestone, argillaceous; Light gray, fine-grained, greenish shale stringers, fusulinids, crinoids, brachiopods…………………………………….…….2.4 ft (0.72 m)

8. Limestone, argillaceous; Light tan to brownish gray, wackestone to packstone, blocky, algal, fusulinids, crinoids, brachiopods………………………………6.6 ft (2.0 m)

7. Shale, calcareous; Greenish-gray, fusulinids………………………0.6 ft (0.18 m)

6. Limestone, argillaceous; Light gray to brownish gray, wackestone to packstone, fusulinids, crinoids, brachiopods……………………………………..1.6 ft (0.48 m)

5. Shale, gray………………………………………………………1.5 ft (0.45 m)

4. Limestone, argillaceous; Light gray to brownish gray, wackestone, fine calcite crystals, moderately-thick beds, brownish-gray shale laminations, crinoids, brachiopods.........................................................................................7.9 ft (2.3 m)

**Stark Shale Member**

3. Shale, clayey; Greenish-gray………………………………………2.0 ft (0.6 m)

2. Shale, black, fissile……………………………………………...1.6 ft (0.48 m)

<u>GALESBURG SHALE</u>

1. Shales and mudstones……………………………………………...7.0 ft (2.1 m)

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# PALEONTOLOGY AND PALEOECOLOGY OF THE PENNSYLVANIAN IN SOUTH-CENTRAL IOWA

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## INTRODUCTION

The Pennsylvanian is known for its coal deposits. In Iowa, these deposits are remnants of peat deposited in coastal and deltaic wetlands (Anderson, 1998). However, much of the Pennsylvanian rock record reflects not the coal swamps themselves, but the dynamic processes of sea level rise and fall which helped make the preservation of coal swamp sediments possible. Transgressions inundated coastal environments, beginning the coal formation process by burying peat deposits. Continued deepening led to the deposition of shallow-water units such as limestones, typically followed by highstand shales. Subsequent sea-level drop permitted the reestablishment of coal swamps in the next cycle. At Thayer and Decatur quarries, these cycles are reflected in an abundance of macroscopic shallow marine taxa—bryozoans, brachiopods, algae, and foraminifera, among others—as well as some plants and marine microfossils.

## COAL SWAMPS

Broadly speaking, Iowa was a low-lying tropical area in the Upper Pennsylvanian. Due to the relatively flat topography, even a minor change in sea level could shift the shoreline considerably and change the depositional environment over large swathes of the state (Anderson, 1998).

Coal swamps of the Iowa Pennsylvanian sprang up in coastal areas, much like modern mangrove swamps and wetlands such as the Everglades. The large extent of some Pennsylvanian coal deposits indicates that these swamps must have contained enormous amounts of biomass. These swamps were dominated by spore-bearing plants which probably enjoyed year-round warm weather (Anderson, 1998). Coal swamp flora in various parts of the world included gigantic seed ferns and lycopods (also known as ‘clubmosses’), some of which may have exceeded 40 m in height (Thomas and Cleal, 1993).

Coal deposits, such as the Davis City Coal of the Galesburg Shale, often occur just above sequence boundaries in the cyclothemic succession. The Galesburg was described by Schutter and Heckel (1985) as a paleosol deposited at lowstand. Schutter (pers. comm. with Witzke, 2010) further specified that the Galesburg was probably “a coastal marsh paleosol, developed during the last subaerial phase of submergence” (based on coloration and presence of coal and pyrite) but subjected to “weathering in a better-drained environment...[at] the acme of the regression” (based on clay mineralogy).

Above the coal bed is a zone of fossiliferous shale, including remains of *Calamites*, horsetail plants which towered 20 meters or more above the floor of the swamp (Thomas and Cleal, 1993). Horsetails are still extant, but the modern version, *Equisetum*, is typically much smaller than its Pennsylvanian counterpart.

Fissile, reflective black shales from this unit can be split to reveal fine striations on the rock; these are the *Calamites* fossils. The *Calamites* layer at Thayer is lenticular, an indication of variable current energy in the depositional environment. Shallow and restricted marine fauna—spirorbid (polychaete) worm tubes, inarticulate brachiopods, and pelecypods—are also present in the zone, providing evidence that these strata represent the beginning of transgression (Heckel and Pope, 1992).

The transition from the Desmoinesian Stage to the Missourian Stage saw a drop in coal bed abundance in the Midcontinent. Schutter and Heckel (1985) attribute this to climate changes bringing drier conditions that discouraged coal forest formation. This was the start of a general shift towards drier conditions in the Permian.

## SHALLOW MARINE DEPOSITS: ALGAE AND FORAMINIFERA

Above the Galesburg Shale is a relatively thin bed of phosphatic shales belonging to the Stark Member. Phosphatic shales may be indicative of sediment starvation. They often exhibit a high spike on gamma ray subsurface logs, since the mud that was deposited at highstand (or maximum marine water depth) accumulated uranium and other radioactive isotopes over time (Thomas Marshall, pers. comm.). The Stark contains orbiculid inarticulate brachiopods, which occur in a variety of depositional settings but can be indicative of dysoxic conditions (Hiatt and Budd, 2003). All these lines of evidence fit the interpretation of these strata as condensed-interval highstand deposits.

The Stark is succeeded by thick deposits of the Winterset Limestone, one of the primary economic limestone deposits mined at these quarries. These beds reflect shallower, warmer marine depositional conditions during the regressive phase of the cyclothem. The Winterset contains a shallowing-upward sequence (Heckel and Pope, 1992). The lowermost beds of the Winterset at Thayer Quarry are limestone with interspersed shale laminations, probably deposited below wave base; fossils such as brachiopods and crinoids are present, but the rock is matrix-supported. Upper beds were deposited above wave base; they contain a wider range of fossils, including some bryozoan pieces. At the Grand River Quarry (not visited on this trip), I observed a burrow filled with fossil hash in the upper Winterset.

The Winterset is notable for its distinctive fusulinid packstone beds. Fusulinids are benthic foraminiferans which are easily recognizable thanks to their distinctive shape, which is suggestive of a flattened football. The Winterset marker bed fusulinids, *Triticites* (probably *T. ohioensis*), are roughly the size and shape of a grain of rice. They are densely packed in some parts of the upper Winterset, although there is significant lateral variation and some parts of the beds have only sparse fusulinids. Lower in the column, in the Bethany Falls, the dominant fusulinid is *Eowaeringella ultima*; this difference in fusulinid faunas aids in distinguishing the two units from one another and in correlating them with units in other parts of North America.

Thompson et al. (1956) commented on the "very prolific fauna of *Triticites*" in the Winterset, based on collections from the Winterset's type locality near Winterset in Madison County. *T. ohioensis* dominates the assemblage, but Thompson et al. also reported "an abnormally large fusulinid near the middle part of the Winterset" at the Winterset quarry; they named this new species *T. winterensis*. *T. ohioensis* is described as "large and highly elongate fusiform in shape with a spirotheca that has a typical and well-developed keriothecal structure (Figure 1). *T. winterensis* (Figure 2) is larger and "has many features which indicate advancement," as Thompson et al. put it. Thompson (1957), as part of a

**Figure 1.** *Triticites ohioensis*, SUI 72456, axial section, from the Winterset Limestone. Rephotographed by Charles Monson.

comprehensive review of Midcontinent Missourian fusulinids, recognized that *winterensis* differed substantially from the type species of *Triticites* and referred it to the genus *Kansanella*, subgenus *Iowanella*.

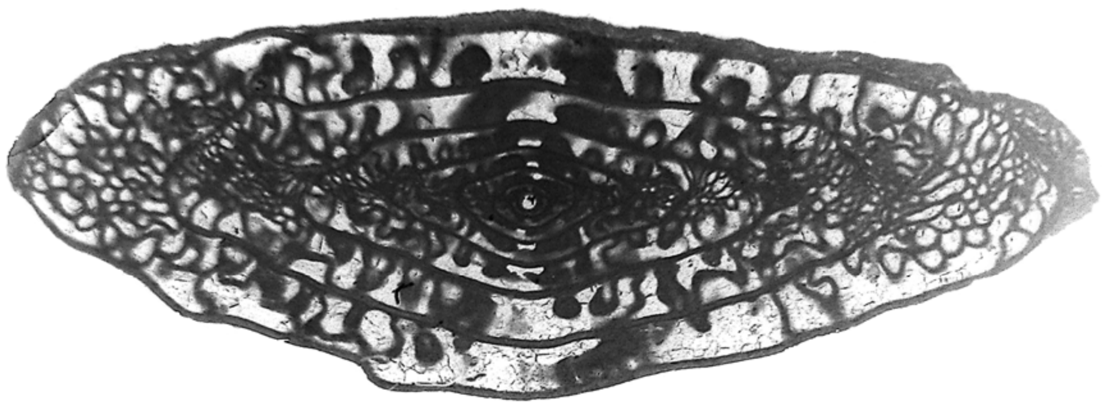

**Figure 2.** *Kansanella* (*Iowanella*) *winterensis*, SUI 72260, axial section, from the Winterset Limestone. Rephotographed by Charles Monson.

Ross (1969) discussed the paleoecology of *Triticites* in the Upper Pennsylvanian of Texas. These organisms lived at the sediment-water interface on shallow carbonate shelves. Ross attempted to relate morphology to environment, suggesting, for example, that thick-shelled species associated with calcarenites (deposited above wave base) were adapted to withstand relatively high wave energy, while thin-walled species might inhabit lagoons and mud flats.

In the uppermost beds of the Winterset, as in many other upper cyclothem limestones in the Midcontinent, we find *Osagia*, a colonial form which consists of algae-foraminiferan intergrowths (Moore, 1964). The intergrowths accrete around a nucleus—typically a shell fragment or rock grain—creating laminated, subspherical to subelliptical pellets. Toomey et al. (1989) argued that such structures should be called “osagid grains,” since the generic term *Osagia* falsely implies a distinct taxon rather than a morphological state that may involve a variety of algae or foram taxa. Nevertheless, the term *Osagia* is still used informally by some workers.

*Osagia* colonies apparently included photosynthetic algae and thus are indicative of photic zone conditions. The grains are coated on all sides, an indication that they were deposited above wave base and were regularly moved by wave action. Upper cyclothem occurrences of *Osagia* may have been deposited in hypersaline waters in lagoons and along shelf margins during regression (Moore, 1964).

The Bethany Falls Limestone also contains photic-zone algal growth—in this case, large plates of phylloid algae (Figure

**Figure 3.** Phylloid algae in Bethany Falls Limestone, Decatur City Quarry, Decatur County, quarter for scale.

3). The term "phylloid" is derived from the Greek term for leaf and refers to the shape of the algal blades. The "leaves" are quite thin but may be up to several centimeters in length. Phylloid algae probably resembled short erect plants with simple cup shapes or with broad "leaves" that dropped off upon death (Baars and Torres, 1991; Scholle and Ulmer-Scholle, 2003). They most likely grew rapidly (Fraser, 1991) and may have been a source of much of the carbonate sediment in some of these limestones (Ball et al., 1977).

Phylloid algae are found in reservoir rocks in some Late Paleozoic deposits. As such, they have been of considerable interest to petroleum geologists. These algae are often described as being analogous to modern seagrass, forming thickets and 'meadows' on the seafloor and possibly encouraging mound growth by baffling sediment. There has been some debate over the extent to which these algae actually influenced seafloor topography (see, for instance, Heckel and Cocke, 1969, and Ball et al., 1977), but it is undeniable that they form a significant component of large-scale features such as mound complexes in Kansas, New Mexico, and Texas (Heckel and Cocke, 1969) and banks in the Illinois Basin (Fraser, 1991). They did not form large-scale ocean floor relief features in the Pennsylvanian of Iowa, however.

Phylloid algae "leaves" in cross-sectional view could be mistaken for shell fragments at first glance. Rocks containing abundant phylloid algae are informally called "potato chip rocks" by some Pennsylvanian workers. Baars and Torres (1991) liken the "leaves" to corn flakes ("Broken calcified remains were often piled up like corn flakes to form prolific reservoir rocks in the Paradox basin…in Kansas, and elsewhere worldwide"). Due to safety considerations, it may not be possible to examine these algae in the quarry wall, but they should be readily visible in large pieces of float at Decatur Quarry.

## WEA SHALE

Thayer Quarry presently features an extensive spoil pile of the Wea Shale which visitors can traverse on foot. This unit has a nodular limestone component, but it is dominated by black highstand shales. The Wea is one of the most fossiliferous deposits in the Pennsylvanian of Iowa (John P. Pope, pers. comm.). As the shale weathers and crumbles, large numbers of marine fossils are freed from the rock. Fossils of the Wea at this location have undergone at least partial silicification, allowing otherwise fragile fossils (such as fenestrate bryozoans) to survive the weathering away of the host rock and allowing morphological features of the fossils to be preserved in great detail.

Wea fossils include a wide range of marine fauna, including abundant brachiopods (such as *Derbyia*, *Juresania*, and *Composita*), pelecypods, ramose bryozoans, and crinoids. Even seemingly nondescript sheets of black shale can yield fossils. Small shell impressions are visible as ribbed, reflective surfaces on bedding planes, and casts of conodont elements are also present on close inspection with a hand lens. Large U-shaped burrows (Figure 4) and slabs representing burrows filled with crinoid hash and *Neochonetes* sp. are present (Figure 5). Field trip participants will be given the opportunity to collect fossils from the Wea spoil pile.

**Figure 4.** U-shaped filled burrow found on spoil pile of Wea Shale at Thayer Quarry, rock hammer for scale.

**Figure 5.** Brachiopods (*Neochonetes* sp.) and crinoid fossil hash in Wea Shale Member of Cherryvale Shale. *Neochonetes* can be identified by half-moon wing-shaped shells. Crinoids are circular disks in the photo. Since these brachiopods and crinoids are marine creatures, geologists infer that the sediment that ultimately turned into the shale was deposited in a marine environment.

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**STOP 2: WEA SHALE MEMBER of CHERRYVALE FORMATION (lower part)**

The following faunal list was provided by John Pope of Northwest Missouri State University. The list was compiled for a 1992 GSI fieldtrip to the Winterset area but is also applicable to the Wea exposure at Thayer Quarry.

**Brachiopods**

*Neospirifer triplicatus*
*Neospirifer triplicatus alatus*
*Neospirifer latus*
*Composita trilobata*
*Composita ovata*
*Composita subtilita*
*Neochonetes* sp.
*Chonetinella flemingi*
*Punctospirifer kentuckyensis*
*Meekella striatocostata*
*Cleiothyridina orbicularis*
*Leptalosia ovalis*
*Derbyia crassa*
*Derbyia bennetti*
*Derbyia* sp.
*Linoproductus prattenianus*
*Linoproductus missouriensis*?
*Linoproductus platyumbonus*
*Linoproductus* sp.
*Dielasma bovidens*
*Orbiculoidea capuliformis*
*Orbiculoidea missouriensis*
*Lingula carbonaria*
*Juresania nebrascensis*
*Pulchratia symmetrica*
*Antiquatonia portlockianus*
*Phricodothyris perplexa*
*Crurithyris planoconvexa*
*Echinaria semipunctatus*

**Trilobite**

*Ameura sangamonensis*

**Bryozoans**

*Megacanthopora* sp.
*Rhabdomeson* sp.
*Rhombopora lepidodendroides*
*Cyclotrypa nebrascensis*
*Fenestrellina*? sp.

*Fenestella*? sp.
*Polypora* sp.
*Septapora* sp.
*Tabulipora* sp.

**Crinoids**

*Delocrinus* sp.
*Aesiocrinus* sp.
*Ethelocrinus* sp.
*Vertigocrinus* sp.
*Apographiocrinus* sp.
*Erisocrinus* sp.
*Stellarocrinus* sp.
*Plaxocrinus* sp.
Many Pirasocrinidae, Cymbiocrinidae, and Ampelocrinidae, plates, stems, and partial cups.

**Worms**

*Spirorbis* sp.
*Serpulopsis* sp.

**Forams**

*Triticites* sp.

**Ostracodes**

Several genera

**Fish teeth**

Cladodont type
*Agassizodus*? sp.
*Caseodus*? sp.
*Petalodus allegheniensis*

**Corals**

*Stereostylus* sp.
*Kionophyllum*? sp.

**Snails**

*Straparollus (Straparollus)* sp.
*Straparollus (Amphiscapha)* sp.
*Bellerophon (Bellerophon)* sp.
*Bellerophon (Pharkidonotus)* sp.
*Platyceras* sp.
*Naticopsis (Naticopsis)* sp.
*Naticopsis (Jedra)* sp.
*Baylea*? sp.

*Goniasma*? sp.
*Donaldina*? sp.
*Trepospira* sp.
Many other genera

**Clams**

*Myalina (Orthomyalina)* sp.
*Myalina (Myalinella)* sp.
*Wilkingia terminale*
*Septamyalina* sp.
*Acanthopecten* sp.
*Aviculopecten* sp.
*Parallelodon* sp.
*Monopteria* sp.
*Streblopteria* sp.
*Clavicosta* sp.
*Clinopistha* sp.
*Nuculopsis* sp.
*Permophorus* sp.
*Edmondia* sp.
*Paleyoldia* sp.
*Phestia* sp.
*Solemya* sp.
*Volsellina* sp.
*Streblochondria* sp.
*Pinna* sp.
*Promytilus* sp.

# PLEISTOCENE GEOLOGY IN DECATUR AND UNION COUNTIES, SOUTH-CENTRAL IOWA

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The field trip area traverses the landform region known as the Southern Iowa Drift Plain (Figure 1). This region is characterized by a succession of pre-Illinoian glacial tills, paleosols, and various inter- and intra-till clays, sands, and gravels capped by a blanket of younger Peoria Loess. This area includes the historic reference sections for the so-called "Nebraskan" and "Kansan" glacial stages as well as the inferred "Aftonian" interglacial stage. Oddly enough, the type section for the "Kansan" glacial stage lies in Union County, Iowa (between Thayer and Afton).

The "Kansan" and "Nebraskan" glacial stages, once considered to be the two oldest glaciations of the Pleistocene, are now known to be an inadequate representation of the complex and numerous Early Pleistocene glaciations that characterized Midwestern United States. This became apparent when the glacial successions of Iowa and Nebraska were re-examined by workers in the 1970s and 1980s (see especially Boellstorff, 1978). Boellstorff found additional sediments below the classic "Kansan-

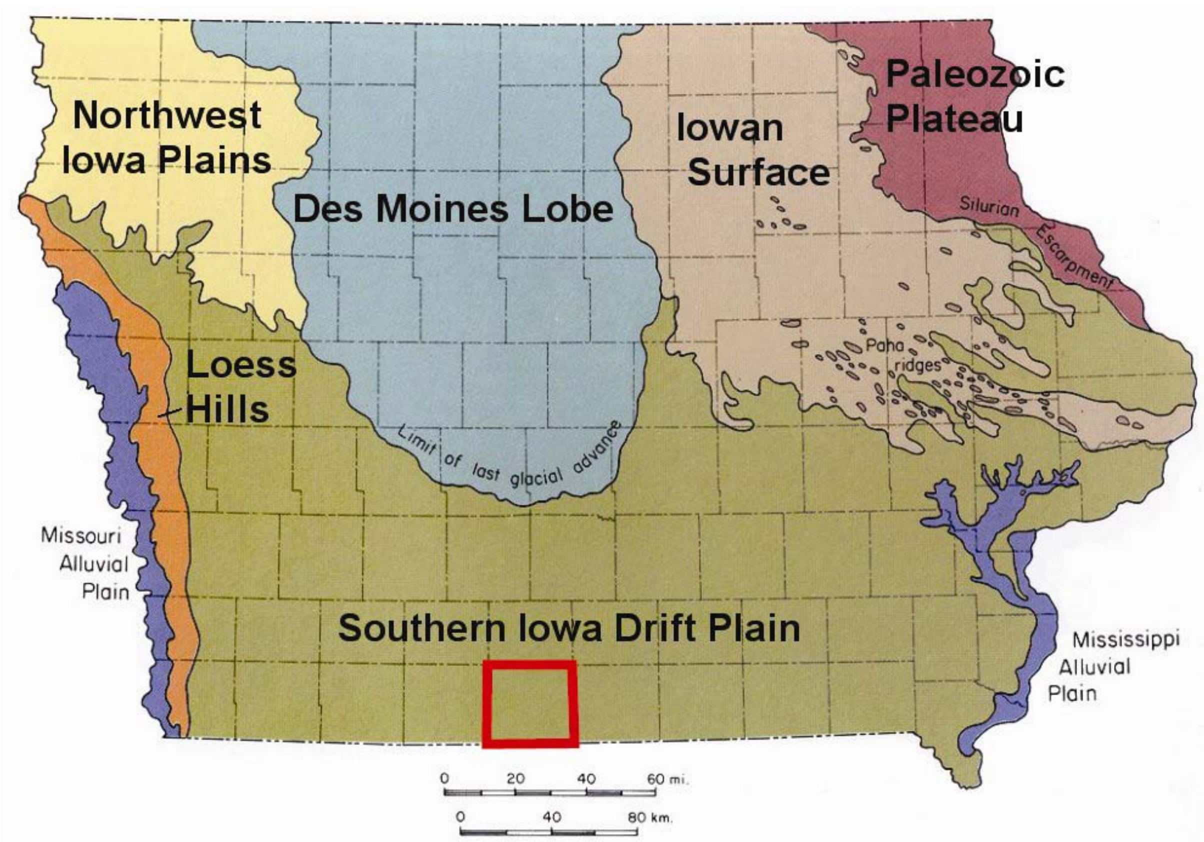


**Figure 1.** Landform regions of Iowa. Red box marks borders of Decatur County, in the Southern Iowa Drift Plain.

Aftonian-Nebraskan" succession in Union County that included a clay-silt unit (with paleosol) and an additional basal glacial till. The clay-silt unit includes a volcanic ash that was dates at 2.2 million years old. It was now clear that the Pleistocene succession of south-central Iowa includes at least three till units (and probably more), each separated by paleosol horizons and interglacial deposits. The pre-Illinoian glacial deposits were given informal names by Boellstorff (A, B, and C tills), but much work remains to be done to formally define the full Pleistocene lithostratigraphy of Iowa. In fact, the Pleistocene remains the most poorly defined portion of the entire Phanerozoic stratigraphic succession in Iowa. Continuing investigations are vitally needed to fully document the Pleistocene succession in Iowa, the best preserved record of Pleistocene continental glaciations in all of North America (if not the world).

Glacial till directly overlies the Pennsylvanian bedrock over much of the field trip area. A very nice clay-rich glacial till east of Lamoni (about 15 feet thick) was visited in preparation for this field trip (GPS location 40.63208, -93.85275). The till at this locality directly overlies Pennsylvanian limestone strata with well-preserved glacial striations on the limestone surface at the contact (Figure 2). The compass-measured orientation of these striations was N5°W with a magnetic declination of N5°E. Therefore, the striations are oriented due north-south at this locality. The clay-rich till contains clasts of igneous, metamorphic, and sedimentary rocks, notably red Sioux Quartzite clasts derived from southern Minnesota. An interesting soft white band (superficially resembling volcanic ash) associated with calcareous concretions occurs near the top of the exposure (Figure 3). It is not presently known which of the several glacial tills in the area is represented at this exposure.

**Figure 2.** Glacial striations on Pennsylvanian limestones in a stream bed, approximately four miles east of Lamoni. Red arrows indicate direction of glacial movement.

**Figure 3.** White, ash-like band associated with calcareous concretions in Pleistocene till overlying glacially-striated Pennsylvanian limestone in Figure 2, approximately four miles east of Lamoni.

**Figure 4.** "Aftonian gravel" at Thayer Quarry, Union County

We were unable to examine the Pleistocene sediments exposed at the Decatur City Quarry, but we hopefully will be able to do so on the field trip. The Thayer Quarry displays a nicely exposed Pleistocene succession that includes glacial till and a prominent sand-gravel unit (Figure 4). Unfortunately, the main exposure is too dangerous to examine up-close (top of high wall). However, the sand-gravel unit can be seen above Pennsylvanian bedrock (apparently incised to a lower level) in a more easily accessible part of the quarry. This sand-gravel unit is well represented in the Afton-Thayer area of Union County where it historically has been termed the "Aftonian gravel." This sand and gravel unit has produced a number of vertebrate fossils in the area (especially teeth) including mammoth, mastodon, horse, and camel (see summary in Rhodes and Semken, 1986). A tooth from a three-toed horse, apparently reworked by Miocene deposits, was also found in the Thayer area (ibid.). Bison is absent from the fauna, supporting an Irvingtonian age (early to mid Pleistocene). The "Aftonian gravels" have been interpreted by most workers to represent interglacial fluvial deposits, coincident with the "Aftonian" paleosol in the non-gravel-bearing till succession (e.g., Calvin, 1909). However, other workers have suggested that the "Aftonian gravels" represent intra-till deposits interstratified within the so-called "Nebraskan" till (e.g., Kay and Miller, 1941). Cleary, further study is warranted.

The only part of the Quaternary succession in the field trip area that seems well constrained and non-controversial is the extensive deposit of wind-blown loess that blankets the older Pleistocene deposits. This is the Peoria Loess, whose wind-deposited silt was sourced from the Missouri River Valley between about 22,000 and 12,500 years ago.

## REFERENCES

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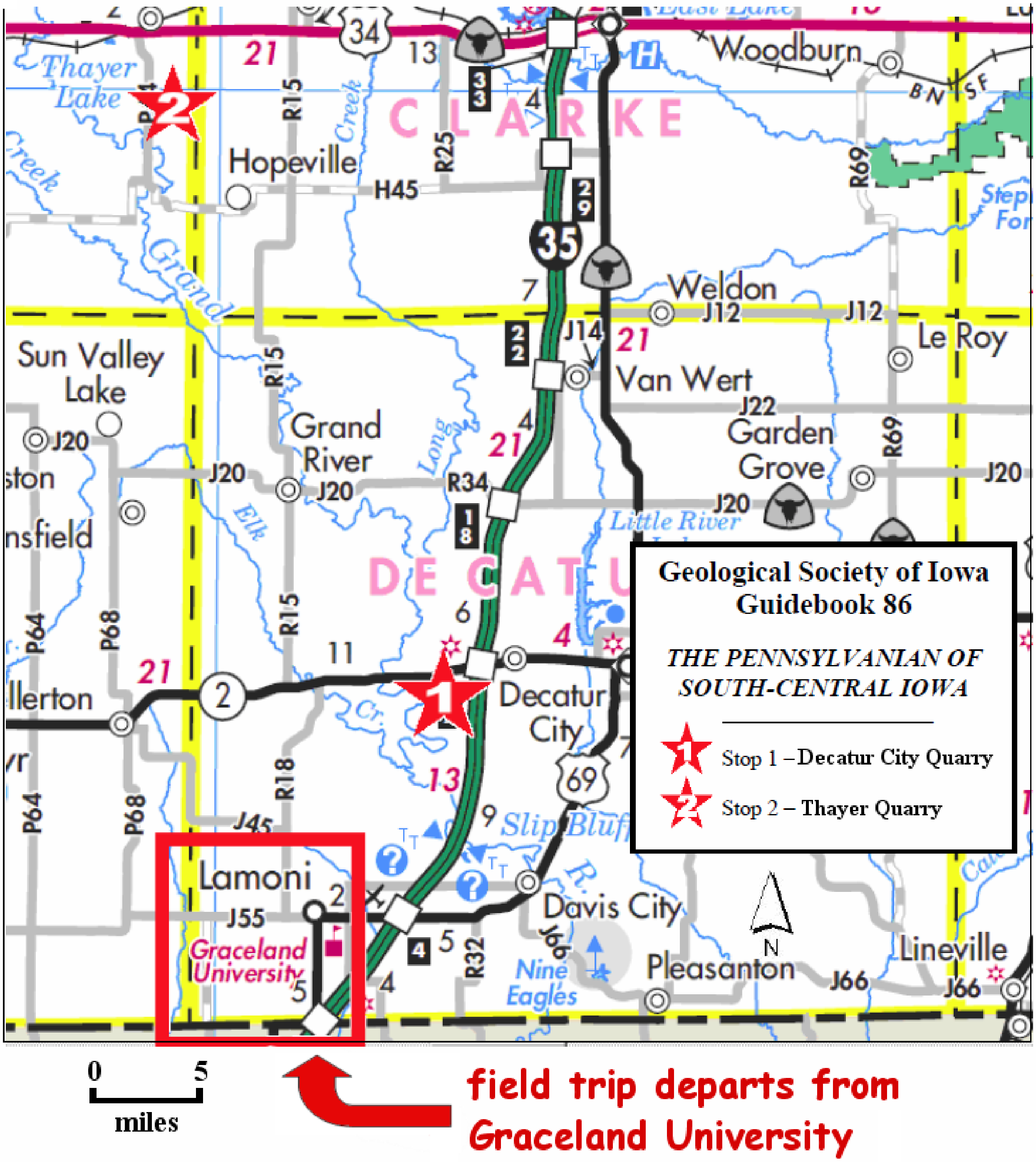
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CLARKE
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Grand River
Garden Grove
Little River
Decatur City
Slip Bluff
Lamoni
Graceland University
Davis City
Pleasanton
Nine Eagles
Lineville
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