Bedrock Geology of Hamburg Quadrangle

Calhoun County, Illinois, and Lincoln and Pike Counties, Missouri

Prairie Research Institute
ILLINOIS STATE GEOLOGICAL SURVEY

STATEMAP Hamburg-BG

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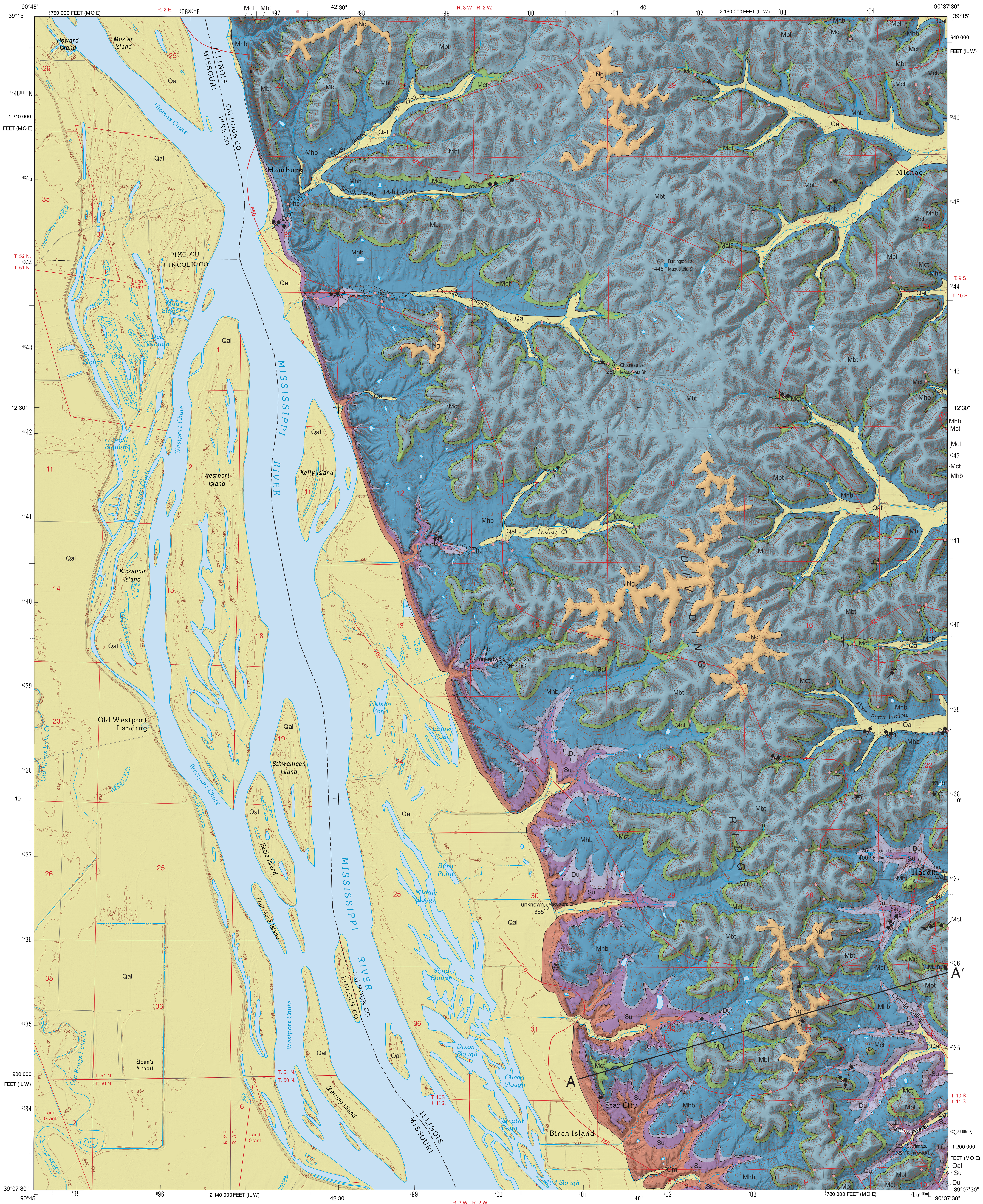
2016



EXPLANATION

Quaternary	Qal	Alluvium	Holocene
Neogene	Ng	Grover Gravel	Pliocene or Miocene
		Unconformity	
Carboniferous (Mississippian)	Mbt	Burlington Limestone	Valmeyeran
	Mct	Chouteau Limestone	Kinderhookian
	Mhb / hc	Hannibal Shale; Horton Creek Limestone Member	
		Unconformity	
Devonian	Du	Devonian undifferentiated: Louisiana Limestone, Saverton Formation, Grassy Creek Shale, Sylamore Sandstone, Cedar Valley Limestone	Upper and upper Middle Devonian
		Unconformity	
Silurian	Su	Silurian undifferentiated: Joliet Limestone, Kankakee Limestone, Bowling Green Limestone	Niagaran and Alexandrian
		Unconformity	
Ordovician	Om	Maquoketa Shale; Noix Oolite Member	Cincinnatian

Symbols

- 40 — Strike and dip of bedding; number indicates degree of dip
- Horizontal bedding
- Vertical joints
- 85 — Inclined joints or fractures; number indicates degree of dip
- Abandoned quarry
- Field note location

Drill Holes

from which subsurface data were obtained

- Stratigraphic boring (ISGS)
- Water-well boring
- Dry oil well
- 65 Burlington Ls. / 445 Maquoketa Sh. — Labels: upper left indicates depth to bedrock; lower left indicates total depth of boring in feet; upper right denotes uppermost formation; lower right denotes formation at bottom. Dot indicates location accurate within 100 feet.

Line Symbols

dashed where inferred, dotted where concealed

- Contact
- 400 — Structure contour of the top of the Chouteau Ls, contour interval 50 feet
- A—A′ — Line of cross section

Note: Well and boring records are on file at the ISGS Geological Records Unit and are available online from the ISGS Web site.

Base map compiled by Illinois State Geological Survey from digital data (2015 US Topo) provided by the United States Geological Survey. Shaded relief and contours derived from 2011 LiDAR (or NED) elevation data.

North American Datum of 1983 (NAD 83)
Projection: Transverse Mercator
10,000-foot ticks: Illinois State Plane Coordinate systems, west zone (Transverse Mercator), Missouri Coordinate System of 1983 (east zone).
1,000-meter grid: Universal Transverse Mercator grid, zone 15

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SCALE 1:24,000

1 1/2 0 1 MILE
1000 0 1000 2000 3000 4000 5000 6000 7000 FEET
1 .5 0 1 KILOMETER

BASE MAP CONTOUR INTERVAL 5 FEET AND 20 FEET
NATIONAL GEODETIC VERTICAL DATUM OF 1988

Geology based on field work by Mary J. Seid, Jeremy R. Breeden, and Stuart M. Kenderes, 2015–2016.

Digital cartography by Jennifer E. Carrell and Donald E. Luman, Illinois State Geological Survey.

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This map has not undergone the formal Illinois Geologic Quadrangle map review process. Whether or when this map will be formally reviewed and published depends on the resources and priorities of the ISGS.

ROAD CLASSIFICATION

Local road

ILLINOIS STATE GEOLOGICAL SURVEY
PRAIRIE RESEARCH INSTITUTE
ILLINOIS
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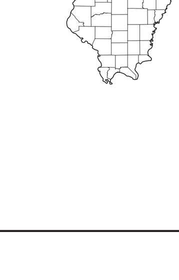
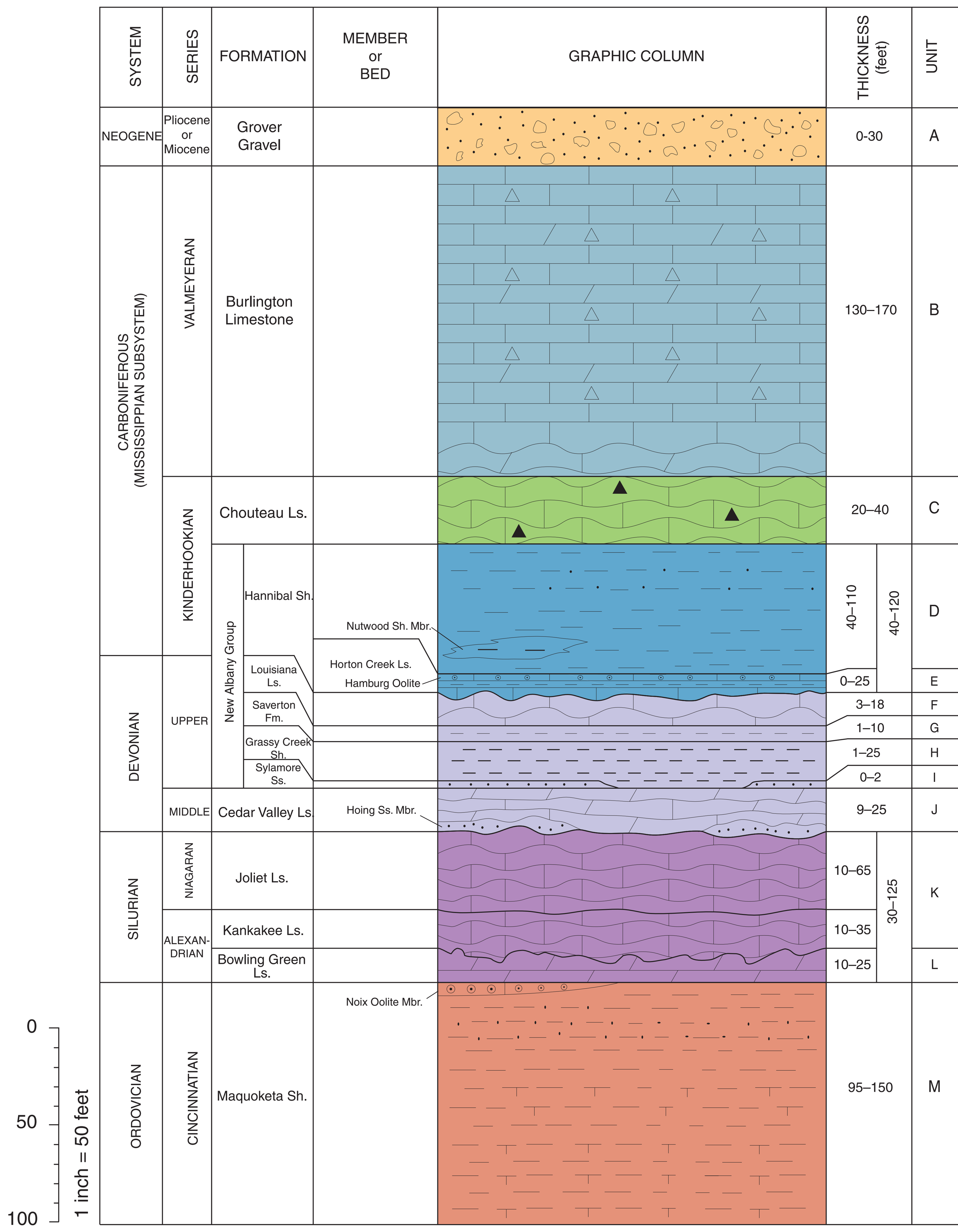


1	2	3
4		5
6	7	8

ADJOINING QUADRANGLES
1 Annada
2 Pleasant Dale Valley
3 Kampsville
4 Elsberry
5 Hardin
7 Foley
6 Luckett Ridge
8 Nutwood

APPROXIMATE MEAN DECLINATION, 2016



A Grover Gravel Chert and sandstone. Outcrops of the Grover Gravel are rare, and in the study area, the unit was only observed in float at the heads of drainages along the Dividing Ridge. The unit consists of lithified conglomerate and unconsolidated sediment containing caramel and red sub-rounded, polished pebbles with a dark reddish brown sandy matrix.

B Burlington Limestone Limestone and chert. Bluff-former and caps the steep hills along the Dividing Ridge. It contains two lithologies which are interbedded with one another. The dominant lithology is light gray to white, medium- to coarse-grained crinoidal packstone to grainstone that is cross-bedded in places. The secondary lithology is yellowish brown dolomitic wackestone to packstone, with coarsely crystalline white crinoidal fragments floating in a yellowish brown very fine- to fine-grained dolostone matrix. Bedding is thin to medium and wavy. The lowermost 5 feet of the unit forms a marker horizon, which is yellowish brown dolomitic limestone that contains solution cavities, vugs, quartz geodes in some places, and forms a re-entrant weathering profile. The chert content increases upward in the formation; the chert consists of white to light gray one- to five-inch-thick bedding-parallel chert in beds or lenses. Disarticulated crinoid stems are dominant, although scattered brachiopods, bryozoans, and corals have been reported. Fossil blastoids that occur in this unit are *Cryptoblastus melo, Globoblastus norwoodi, Schizoblastus sayi* and *Schizoblastus aplatus*. Brachiopods include *Dictyoclostus burlingtonensis*, *Spirifer grimesi* and *Rhipidomella burlingtonensis*. The basal contact ranges from gradational to sharp.

C Chouteau Limestone Limestone and chert. In the southern part of the quadrangle, the Chouteau is medium gray shaly lime wackestone, with thin wavy bedding and minor amounts of bedding parallel chert. In the northern part of the quadrangle, the Chouteau is olive brownish gray to yellowish greenish gray silty argillaceous mudstone, in thin wavy beds, and it gradually becomes more crinoidal upward, forming a gradational contact with the overlying Burlington Limestone. It contains abundant calcite geodes, an occasional brachiopod, and sparse colonial corals with small tubular corallites. The gastropod *Straparollus* is relatively common and reaches 5-7 cm in diameter. The contact between the Chouteau Limestone and Hannibal Shale is gradational in some places and sharp in other places.

D Hannibal Shale Shale and siltstone. Light greenish gray siltstone and medium gray silty shale, contains light gray calcareous siltstone stringers and pyrite. Forms slopes and is often poorly exposed. The Nutwood Shale Member is not well-developed in the quadrangle, but it does contain elevated carbon content (2.05%TOC) relative to the other parts of the formation. Small carbonaceous fragments and bioturbation occur within the siltstone facies. Fossils in the Hannibal are sparse and seem to only occur within the uppermost beds. The basal contact is sharp with the Horton Creek below.

E Horton Creek Limestone Member of the Hannibal Shale Limestone and shale. Thin and discontinuous unit exposed in Indian Creek, Gresham Hollow, Irish Hollow, Poor Farm Hollow, Lincoln Valley, and on A. Schleeper Road. The basal part of the Horton Creek is medium gray limestone, shale, and siltstone with low-angle micro cross-bedding. The middle greenish gray silty shale of the Horton Creek Member is divided from the overlying Hannibal Shale by the Hamburg Oolite bed. The uppermost Hamburg Oolite bed is 2.5 to 3 feet thick dark gray to brown packstone with disarticulated brachiopods and crinoids. It is exposed as inconspicuous ledges just above road level at the mouths of Godar and DeGerlia Hollows. Thin sections indicate that the "oolites" are actually coated sand grains and lack the features of well-developed oolites (i.e. concentric calcite rims). The oolitic beds also contain rounded rip-up clasts of Louisiana Limestone in Gresham Hollow. Fossils in the Horton Creek include *Chonetes, Rhynchopora hamburgensis, Dielasmella calhounensis* and *Delthyris missouriensis* (brachiopods), *Schizodus appressus* and *Parallelodon sulcatus* (bivalves). The contact between the Louisiana and Horton Creek is wavy, sharp, erosional, and unconformable.

F Louisiana Limestone Limestone. Light grayish brown lithographic lime mudstone, wavy bedded throughout, conchoidal fracture when broken, contains some greenish gray mottling. Weathers white to light gray, and very smooth. The unit contains articulated brachiopods, spiriferids, productids, and the genera *Ripidomella, Pixidixia, Athyris marionensis* and *Cyrtina sp.* Calcite nodules in the form of neomorphic spar occur along some bedding planes. The basal contact is razor sharp with the Saverton below.

G Saverton Formation Siltstone. Light greenish gray bioturbated, non-calcareous siltstone. Contains clear, well-rounded fine quartz sand and an occasional sub-rounded phosphatic pebble. The Saverton Formation was not observed in outcrop anywhere in the quadrangle, and is only 0.6 feet thick in the Fanning #1 stratigraphic corehole. The basal contact is gradational and interfingers with the underlying formation.

H Grassy Creek Shale Shale. Dark gray non-calcareous shale. The Grassy Creek Shale was only 0.2 feet thick in the Fanning #1 corehole and was not observed in outcrop anywhere in the quadrangle. No fossils were observed from the Grassy Creek. The lower contact is corrugated and unconformable.

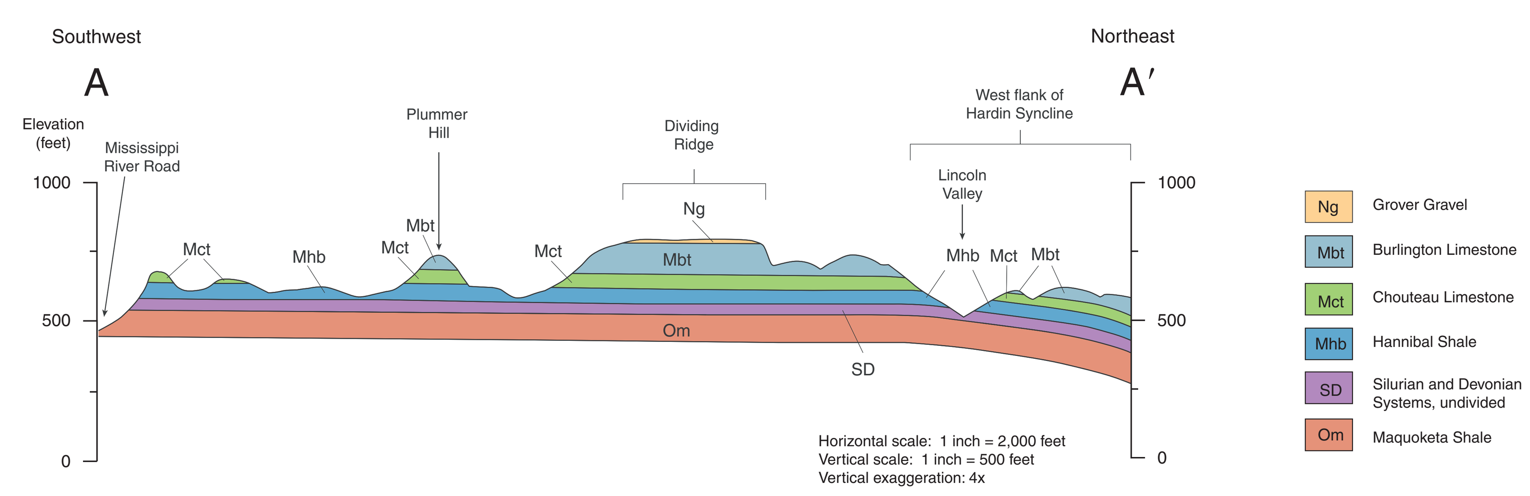
I Sylamore Sandstone Sandstone. The Sylamore was not observed in the study area but may occur as a very thin and discontinuous layer of fine-grained quartz arenite sandstone. The lower contact is unconformable with the underlying Cedar Valley.

J Cedar Valley Limestone Limestone. Light brownish gray fine-grained wackestone to grainstone, yellowish brown weathered, dolomitic in part, beds thin to medium and wavy. In outcrop, microkarst is developed on the underside of beds and weathers with 0.75-inch holes. In places, brachiopod shells contain purplish calcite. A two-foot-thick chert conglomerate layer is present in some areas at the base of the unit--it was well-exposed on the north side of A. Schleeper Road (Sec. 3, T11S, R2W). The Hoing Sandstone Member is a very thin, fine-grained, well-rounded, light brown quartz arenite that occurs at the base of the Cedar Valley in Secs. 4 and 10, T11S, R2W. The Hoing Sandstone Member fills joint crevices in Silurian limestone at the mouth of Gresham Hollow. Where the Hoing Sandstone is not well-developed, the chert conglomerate layer contains clean quartz sand grains (Secs. 3 and 10, T11S, R2W). The Cedar Valley Limestone is the most fossiliferous unit in the study area, and the large size of the fossils is diagnostic. The fauna consists of ramose and lace-like *Fenestella* bryozoans, *Syringopora* colonial and *Cystiphyllum* rugose corals, crinoid stems, spirifers, *Syringospira* and *Tylothyris* brachiopods, and *Stromatoporid* sponge heads. The basal contact is unconformable, sharp, and contains rounded clasts of the unit below.

K Joliet Limestone and Kankakee Limestone Limestone. The two formations are lithologically very similar and could not be differentiated in outcrop. The contact between the Kankakee and Joliet is disconformable and based on a faunal change. The two formations may be divided in drill core by an isotopic excursion. The Kankakee and Joliet Limestones consist of light gray, dense, very finely crystalline grainstone. Beds are undulatory, bioturbated, and dominantly thin to medium but appear massive. Greenish clay stringers, a reddish tint, and bed-parallel stylolites are common. Thin sections indicate that echinoderm fragments are dominant, but trilobite, rhomboperoid bryozoans, ostracodes, and chitinozoans are also present. Sparse amounts of glauconite and chalcedony are present. The upper one foot of the Joliet contains fine-grained silica sand on the north side of A. Schleeper Road. At the mouth of Gresham Hollow, light brown fine- to medium-grained quartz arenite sandstone with gray and white subangular chert pebbles (Hoing Sandstone?) was lithified in overhangs and joints. This relationship suggests that the sandstone was deposited in a Silurian paleokarst topography. At the mouth of Irish Hollow in Hamburg, abundant *Orthoceras* sp. cephalopods exceeding 1 foot in length were found on weathered bedding planes. The contact between the Bowling Green and Kankakee has up to five feet of relief at the mouth of Indian Creek and at several localities on the east side of Mississippi River Road.

L Bowling Green Formation Dolostone. Light brown microgranular dolomitic mudstone, weathers medium yellowish brown, with moldic porosity and a chalky texture. Bedding ranges from 6 inches to 3 feet thick, is planar bedded, and contains stylolitic sutures between beds. The basal contact is sharp and contains abundant pyrite and glauconite.

M Maquoketa Shale Shale. Greenish gray slightly silty fissile shale and shaly siltstone. The Noix Oolite Member at the top of the unit is white to brownish gray oolitic grainstone in a 3-foot-thick massive bed. The basal 3 inches of the Noix contain conspicuous glauconite, pyrite, and phosphatic pebbles 2 to 7 mm in diameter. The Noix Member was observed in Sec. 13, T10S, R3W, and Sec. 32, T10S, R2W. The basal contact of the Maquoketa is not exposed in the study area.



Introduction

The Hamburg Quadrangle is located in western Illinois, on the border between the Ozark Uplift and the Illinois Basin (Fig. 1). The bedrock is Ordovician through lower Mississippian in age and consists of limestone, dolostone, shale, and minor amounts of sandstone. Thin Pliocene or Miocene Grover Gravel caps the uplands in parts of the study area (Rubey 1952). Calhoun County is in a driftless area, but windblown loess from the Illinois and Wisconsin episode glaciations reaches 25 feet in thickness and blankets the landscape throughout the entire quadrangle (Fehrenbacher et al. 1986).

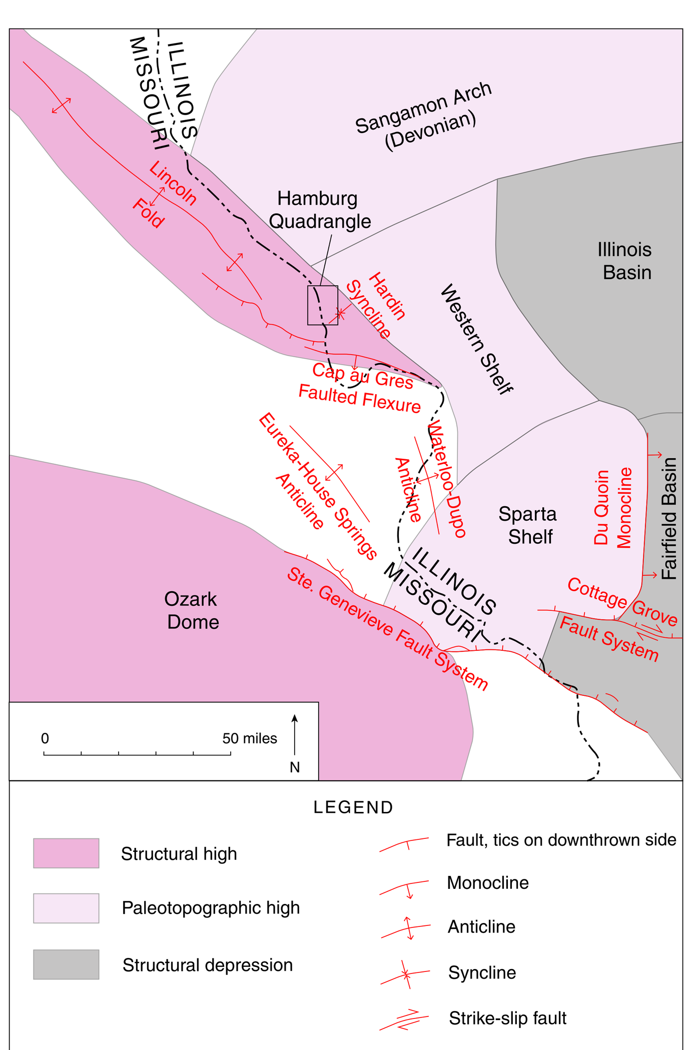


Figure 1 Principal structural features of west-central Illinois and east-central Missouri. Modified from Anderson (1988).

Methods

Traverses on foot were conducted in tributaries of minor and major drainages. The Fanning #1 stratigraphic corehole (Sec. 5, T10S, R2W) was drilled to collect subsurface samples of the Hannibal Shale through the Maquoketa Shale and conduct total organic carbon (TOC) and isotope analyses. Lithologic and stratigraphic information from water well and oil test hole records were examined from the Illinois State Geological Survey's Geological Records Unit. Rock units were correlated from natural outcrops to the subsurface data (core hole and well records), and formation contacts were projected through areas with no outcrops. Field observation locations and well borings are indicated on the geologic map.

Structural Geology

A structure contour map on top of the Chouteau Limestone was constructed from outcrop and borehole data and shows that the general dip of bedrock is 1˚ to the northeast into the Illinois Basin (Fig. 2). Contours are more closely spaced on the eastern edge of the quadrangle near Hardin where beds dip into the Hardin Syncline.

The dissected topography is controlled by the bedrock structure. Creek drainages tend to flow down-dip on tilted bedding planes, follow the strike of bedding, or preferentially flow along sub-vertical joints in bedrock. A rose diagram compiled from 47 joint measurements indicates that the most common joint trend is N 39˚ E to N 49˚ E (Fig. 3).

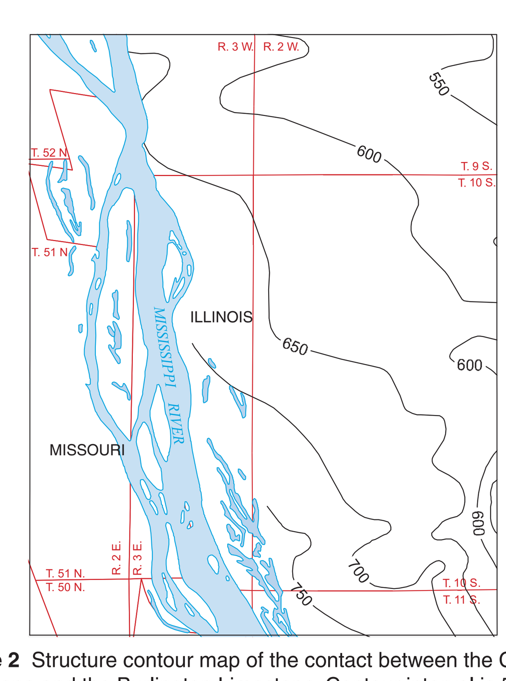


Figure 2 Structure contour map of the contact between the Chouteau Limestone and the Burlington Limestone. Contour interval is 50 feet. Map scale is 1:125,000.

Hardin Syncline

The Hardin Syncline is a northwest-trending doubly plunging syncline that disrupts the bedrock in and around the town of Hardin. A small portion of the fold is present in the eastern part of the quadrangle. The average dip on the flanks of the syncline is 5˚ on the southwest limb and 9˚ on the northeast limb. Local faulting and closely spaced joints are present on the southwestern limb of the fold to the west of Hardin (2,500 ft. WL, 1,500 ft. SL, Sec. 27, T10S, R2W).

The major movement on the Hardin Syncline was probably coincident with the major displacement event of the Cap au Grès faulted flexure, which occurred after the deposition of the Mississippian St. Louis Limestone and before the Pennsylvanian (Rubey 1952). The structure was also active multiple times earlier in the Paleozoic. These earlier movements affected the thicknesses of many of the units between the base of the Silurian Bowling Green Limestone and the top of the Mississippian Hannibal Shale in the vicinity of the Hardin Syncline. Silurian and basal Mississippian units are 50% thinner on the southwestern limb of the syncline than throughout the rest of the quadrangle. The combined Silurian units are only 50 feet thick and the Hannibal Shale is only 40 feet thick in Lincoln Valley, whereas the Silurian units are 101 feet thick and the Hannibal is more than 100 feet thick in the Fanning #1 borehole in Gresham Hollow.

Deep-seated basement faults underlie many structures in the Illinois Basin and Ozark Uplift region that were reactivated throughout the Paleozoic (Nelson and Lumm 1985, Nelson 1995). It is possible that the Hardin Syncline is rooted in basement and was a slight high during the Silurian, Devonian, and early Mississippian. The basement fault may have been reactivated post-Mississippian as a compressional feature and formed a syncline by fault-propagation folding.

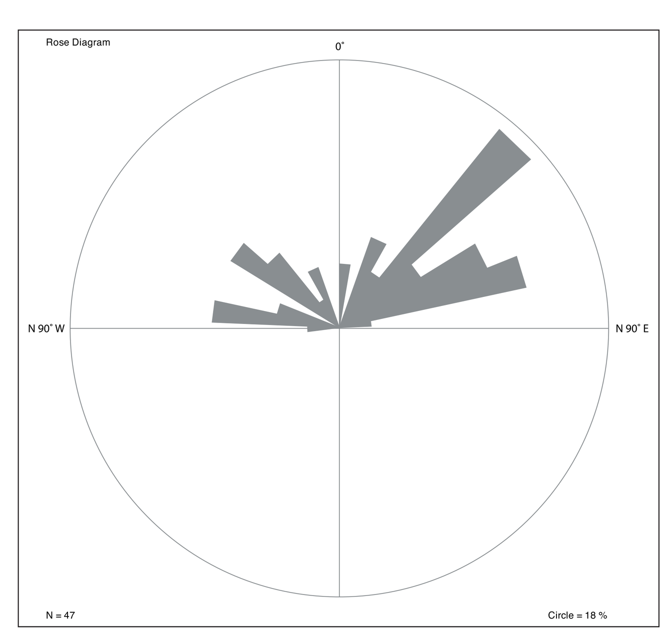


Figure 3 Rose diagram of 47 subvertical joint measurements within the quadrangle. Half-circle plot; petal size is 9.75˚. The dominant joint orientation is between N 39˚ E to N 49˚ E.

Economic Geology

Limestone

The only quarry in the quadrangle is along Rocky Hill Road west of Hardin (Sec. 28, T10S, R2W). It is a small abandoned quarry in the high-calcium basal Burlington Limestone that likely provided aggregate for local roads and construction.

Oil

Two oil test holes were drilled in the quadrangle, and neither produced any oil. Shales of the New Albany Group, which are source rocks in the deeper parts of the Illinois Basin, are present in the quadrangle. Total organic carbon content (% TOC) from potential source horizons in the Grassy Creek Shale, Saverton Shale, and Hannibal Shale (New Albany Group) from the Fanning #1 core hole were analyzed during the study.

The bulk total organic carbon (TOC), organic $\delta^{13}C$ values, and Ti/Al ratios can provide information regarding the likely maturation of hydrocarbons within a shale unit, such as the New Albany Group. The Grassy Creek and Saverton Shales (Devonian) contained a maximum of 0.48% TOC, which is relatively low. Within the Hannibal Shale (Mississippian), there were two zones with elevated TOC values ranging from 0.5% at 50 feet to 1.5% at 76.5 feet (Fig. 4). These zones show corresponding trends in $\delta^{13}C$ values and TOC values with TOC values increasing as $\delta^{13}C$ values decrease. There is also an increase in Ti/Al ratios over these two zones. This suggests a change from a predominantly marine to C3 terrestrial source as $\delta^{13}C$ values decrease, as well as increased sedimentation rates as Ti/Al values increase. If terrestrially sourced organic matter matures thermally, it is most likely going to generate dry-gas. However, the TOC values in the Hannibal Shale are lower than other shale oil and gas source rocks such as the Marcellus Shale (>6.5% TOC) and Bakken Shale (11% TOC).

Groundwater

Surficial deposits are the primary groundwater source in Calhoun County, and wells producing water from bedrock units are much less common. The Mississippi River Valley contains sandy alluvial deposits about 100 feet thick that are suitable for high-capacity wells (Woller 1975). Natural limestone springs in the Chouteau Formation are fairly common and have been used as sources for small domestic use. Small to moderate-sized groundwater supplies are available from the Silurian and Devonian units, as well as from the Ordovician St. Peter Sandstone in the Mississippi River Valley south of Hardin. However, north of Hardin, the water in the St. Peter Sandstone is too highly mineralized for domestic use (Woller et al. 1990).

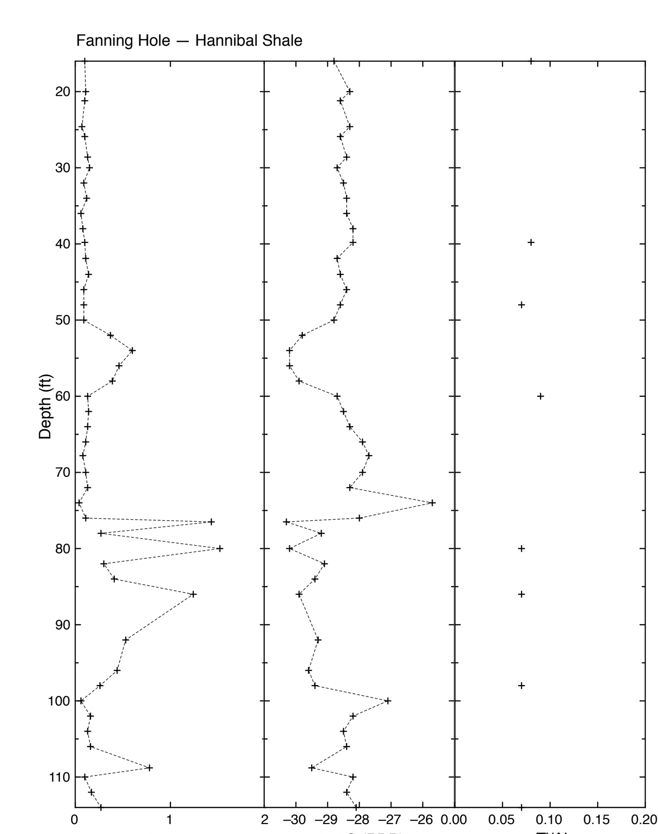


Figure 4 Total organic carbon (% TOC) content, $\delta^{13}C$ values, and Ti/Al ratios in the Hannibal Shale from the Fanning #1 core hole in Sec. 5, T10S, R2W. Plus signs represent data points.

Silurian Ireviken Excursion Event

Carbon isotopes were analyzed within the Silurian section of the Fanning #1 core to enable stratigraphic correlations across the Illinois Basin. The Ireviken excursion occurs at 189 feet total depth, and the $\delta^{13}C$ mean values rise from +3.8 permil to +6.3 permil across that boundary (Fig. 5). This indicates an increase in primary oceanic productivity. The Ireviken excursion is coincident with the end of the Llandovery and the beginning of the Wenlock series (Telychian/Sheinwoodian stage boundary). Conodont and trilobite data prove that the rocks in which the excursion occurs are the correct age for the Ireviken and not one of the younger Silurian excursions (D. Mikulic, personal communication, July 29, 2016).

Acknowledgements

We thank Ed and Patty Fanning for allowing us to collect a stratigraphic core on their property, as well as many other landowners who granted us permission to study outcrops. Jeremy Breeden and Stuart Kenderes assisted in field work. Jeremy Breeden, Joe Devera, and Donald Mikulic analyzed stable carbon isotopes in the Silurian section and provided interpretation. Stuart Kenderes, Cheryl Kelley (University of Missouri), and Brett Denny analyzed the total organic carbon content and stable carbon isotopes of the New Albany Shale Group.

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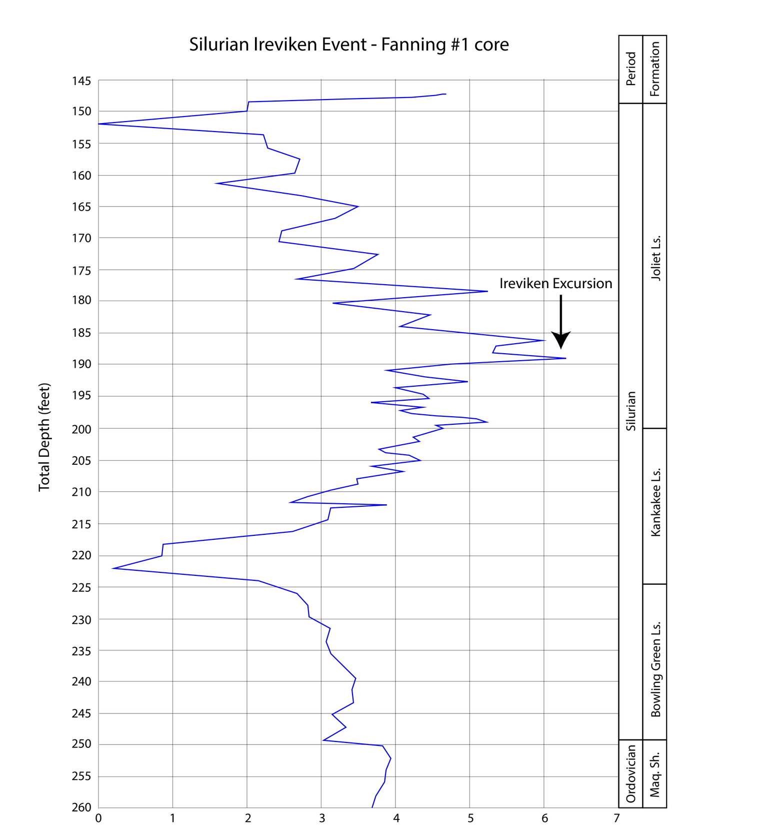

Figure 5. Plot of $\delta^{13}C$values in the Silurian section of the Fanning #1 core. The peak at about 189 feet depth is the Ireviken isotope excursion event, which occurs in the basal Joliet Limestone. Maq. Sh. = Maquoketa Shale.

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