

Bedrock Geology of Hardin Quadrangle

Greene, Calhoun, and Jersey Counties, Illinois

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Introduction

The Hardin Quadrangle is located in an area with a complex Paleozoic and Quaternary history. On the border between the Ozark Uplift and the Illinois Basin, the quadrangle is located on the northeastern flank of the Lincoln Anticline and north of the Cap au Grès faulted flexure. The bedrock layers are dominated by carbonate and shale, and within the quadrangle, several unconformities and variations in thickness occur, especially in the Silurian and Devonian units. The Illinois episode glacial boundary occurs approximately along the Illinois River and glacial till covers most of Greene and Jersey Counties, although Calhoun County was never glaciated. Thick loess from the Illinois and Wisconsin episode glaciations blankets the landscape throughout the entire quadrangle.

In Calhoun County and the western edges of Jersey and Greene counties, where glacial till and outwash is thin or not present, the topography is controlled by the structure of the bedrock. 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 notable feature that impacts the local drainage pattern is the Hardin Syncline. The structure of the syncline is evident from the topography within a one-mile radius of Hardin, with drainages following dip-slopes or the strike of the bedding. The regional dip of bedrock is to the northeast into the Illinois Basin, and the long, straight trend of Haushalter Hollow reflects the regional dip. Other areas, like the tributaries to Shaw Hollow, follow the local jointing pattern.

Methods

Traverses on foot were conducted in tributaries of minor and major drainages. The Juhl #1 stratigraphic corehole (Greene Co., Sec. 9, T. 9 N., R. 13 W.) was drilled to collect subsurface samples of the bedrock units, some of which were not exposed in natural outcrops. 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 where direct observation was not possible. Field observation locations and well borings are indicated on the geologic map. A structure contour map on top of the Chouteau Limestone was constructed using numerous locations where the elevation of the contact was observed in the field between the Chouteau Limestone and the Burlington Limestone. Strike and dip data was also used in producing the structure contour map, which shows the general structure of the bedrock. Soils maps downloaded for each county from the U.S. Department of Agriculture Natural Resource Conservation Service database (Soil Survey Staff), along with Official Soil Series Descriptions (Soil Survey Staff) were utilized in mapping the surficial deposits.

Stratigraphy

Ordovician

The Maquoketa Shale contains the Noix Ooilte Member, which was assigned to the late Ordovician by Thompson and Satterfield (1975). The Noix Oolite used to be included in the basal Silurian Edgewood Group (Rubey 1952). Its type section is 40 miles northwest of the quadrangle near the mouth of Noix Creek in Louisiana, Missouri (Thompson 2001).

Silurian

Nomenclature of Silurian units is confusing because several unique lithologies and unconformities occur in western Illinois, which is on the edge of the Illinois Basin. In the southwestern part of the quadrangle, they are only 50 feet thick in total. Only 5 miles away, in the Juhl #1 core hole in the northern part of the quadrangle, the three Silurian formations are 121 feet thick in total.

The name Bowling Green Limestone was used for the basal Silurian formation within the study area. The Bowling Green Limestone was considered a member within the Edgewood Formation of Rubey (1952). During this study, exposures of the Bowling Green Dolomite in Missouri (Thompson 1993) were visited in the town of Bowling Green, and the yellowish brown, chalky, tabular bedded, dolomitic limestone was identical to the lithology of the unit exposed in the Hardin Quadrangle on A. Schleeper Road. Unweathered Bowling Green is reportedly a distinct bluish gray limestone in Missouri (Thompson 1993), but in the Juhl #1 core hole, although not bluish, the unweathered rock was a light brownish gray non-dolomitic lime mudstone. Summaries by Thompson (1993) and Rubey (1952) provide a thorough history of the nomenclature of this unit.

Overlying the Bowling Green Limestone are the Kankakee and Joliet Limestones. In the Juhl #1 core hole and in exposures along A. Schleeper Road and in Lincoln Valley, the Kankakee Limestone and Joliet Limestone could not be separated on a lithologic basis, so they were combined in the geologic column. Thin sections from the Joliet-Kankakee Limestone unit indicate that echinoderm fragments are dominant, but trilobite, rhomboperoid bryozoans, ostracodes, and chitinozoans are also present. One of the samples (MS-12) is a wackestone to packstone that contains neomorphic spar and a burrowed texture in places, which suggests a shallow lagoon or harbored shelf environment. The other sample (MS-205A) contains sparse amounts of glauconite and chalcedony and is a mudstone to wackestone that consists of very small fossil fragments throughout, which suggests a quieter, off-reef environment.

A faunal break was reported between the Kankakee Limestone and Joliet Limestone (Savage 1926) in an exposure five miles to the northwest near the Hamburg Church. Rubey (1952) indicated that the contact between the two forma-



Depth downhole (feet) tions is placed "at a prominent but very smooth bedding plane", a feature which could not be identified during this study despite several visits to the outcrops below the Hamburg Church. The Kankakee Limestone is separated from

142 143 144 145 146 147 148 149 150 151

the Bowling Green Limestone by a significant erosional unconformity with as much as 5 feet of relief on the surface. This feature is well exposed in a few places in the adjacent Hamburg Quadrangle and on Kissenger Bluff in Missouri. In Missouri, Thompson (1993) used the term "Joliet Limestone" (with quotes) for the light gray limestone overlying the Bowling Green Limestone.

The name Kankakee Limestone has been in use for the past 15 years for the middle Silurian formation in western Illinois (Denny and Devera 2002, Seid and Devera 2008a, Seid and Devera 2008b, Devera and Seid 2008, and Devera 2010). Savage (1926) used the name Kankakee Limestone, but later he suggested the use of Brassfield Limestone to Rubey (1952). Krey (1924) and Lamar (1926) called this unit the Sexton Creek Limestone, a name that is still in use for rocks of this age in southern Illinois.

The name Joliet Limestone is well established in the area and has been in use for exposures from Grafton to Hamburg for nearly 100 years (Savage 1926).

Devonian

Devonian formations in the study area are each 25 feet thick or less, and their combined thickness ranges from 40 to 60 feet, so they were combined in order to form a mappable unit on the 1:24,000 scale map.

The Upper Middle Devonian Cedar Valley Limestone of this report is the same as that of Rubey (1952), although Rubey wrongly assigned it to the Upper Devonian. The Sylamore Sandstone is a very thin quartz arenite sandstone layer that overlies the Cedar Valley Limestone. It was not present in the Juhl #1 core hole but is known to occur 5 miles to the west near the Hamburg Methodist Church (Hamburg South Section, Koenig et al. 1961). The Grassy Creek Shale and Saverton Shale overlie the Sylamore Sandstone. These two shale units are relatively thin and were included at the base of the Louisiana Limestone in Rubey (1952). The Grassy Creek Shale and Saverton Shale were analyzed for carbon content (%C) from the Juhl #1 core hole in order to assess their potential as source rocks at the western edge of the Illinois Basin, and the results are shown in Figures 1 and 2. The Grassy Creek Shale contained a much greater amount of carbon (1.55%) than the Saverton Shale (0.27%). Data from more core holes would be useful to determine the trends throughout the region.

For many years, the age of the Louisiana Limestone had

been debated as early Mississippian or Late Devonian, but the Sylamore Sandstone, Grassy Creek Shale, Saverton Shale, and Louisiana Limestone were finally assigned to the Devonian when a Devonian conodont fauna was found in the Louisiana Limestone (Scott and Collinson 1961).

Mississippian

The Horton Creek Limestone Member of the Hannibal Shale (Conkin and Conkin 1973), which includes the Hamburg Oolite Bed (Weller 1906, p. 464), was shown on the map by a stippled pattern where it was observed in outcrop, but in the remainder of the quadrangle, it was mapped together with the Hannibal Shale. The Horton Creek Limestone Member was formerly known as the Glen Park Formation (Rubey 1952). Its name was changed from Glen Park to Horton Creek once the type-Glen Park in Missouri, although similar in lithology and fauna, was found to be slightly older (Devonian) than the beds in the Hardin and Hamburg areas (Mississippian) (Thompson 2001).

In Poor Farm Hollow, the base of the Horton Creek Limestone Member contains rounded, imbricated clasts (Fig. 3). The top of the formation is marked by the Hamburg Oolite Bed, which is exposed as inconspicuous ledges just above road level in Poor Farm Hollow and at the mouths of Godar and DeGerlia Hollows. It is a 2.5 to 3 foot-thick massive brown limestone bed which contains conspicuous carbonatecoated sand grains (Fig. 4). Oolites in the Hamburg Oolite Bed lack concentric calcite rims, which suggests that the oolites are poorly developed. The oolitic beds also contain rounded rip-up clasts of Louisiana Limestone in the adjacent Hamburg Quadrangle.

In the study area, the Hannibal Shale also contains the Nutwood Shale Member, which is darker gray and more carbonaceous than the rest of the formation. Carbon (C) analyses were performed at two foot intervals in the Juhl #1 core hole, and results are shown in Figure 5. The unit contains a maximum of 2.05%C at a horizon 18 feet above the top of the Horton Creek Limestone Member. This value is below the 6 to 14% C values that the New Albany Shale Group contains in southeastern Illinois (Strapoc et al. 2010), and gray shale with values of only 1 to 2%C are unlikely to have generated significant amounts of hydrocarbons (Barrows 1984). However, the interval between 101 and 105 footages in figure 5 may represent the nutwood member.

The Chouteau Limestone was originally named from exposures in central Missouri (Swallow 1855), and Worthen (1870) correlated the Chouteau Limestone as the upper unit of the Kinderhookian in Illinois. The name has remained unchanged for 145 years. Measured sections indicate that the thickness of the Chouteau Limestone is greatest in the southwestern portion of the quadrangle, toward the Lincoln Fold, and it is thinnest in the northern and eastern parts of the quadrangle.

The contact between the Chouteau Limestone and Burlington Limestone ranges from sharp to gradational throughout the quadrangle. In the southern half of the Hardin Quadrangle, there is a sharp change in bioclastic content between the Chouteau Limestone and the Burlington Limestone--the



Figure 3 The base of the Horton Creek Limestone Member is cross-bedded and contains rounded, imbricated clasts in Poor Farm Hollow (MS note 10). December 6, 2014. Chouteau is an argillaceous wackestone containing about 5% crinoidal fragments, and the Burlington is a packstone to grainstone containing about 50% to 90% crinoidal debris. However, in the northern portion of the Hardin Quadrangle, the bedding character, clay content, and bioclastic content are gradational between the Burlington and Chouteau in a 3-foot-thick transition zone, and the approximate contact between the formations may be placed where the bioclastic content markedly increases.

In other 1:24,000 scale maps in the area, the Burlington and Keokuk Limestones have been combined as a single unit because of their lithologic similarities, namely their coarse crinoidal texture and light brownish gray color (Denny and Devera 2002, Devera and Seid 2008, Seid and Devera 2008a, Seid and Devera 2008b, and Devera 2010). However, in the Hardin Quadrangle, the base of the Keokuk Limestone is marked by the Montrose Chert Member, which forms a distinct marker bed. It is 10 to 15 feet of gnarly, massive, angular brecciated chert (Fig. 6). The elevations of several exposures of the Montrose Chert Member were coupled with the structure contour map to calculate the thickness of the Burlington Limestone. Knowing the thickness of the Burlington Limestone allowed projection of the contact between the Burlington and Keokuk Limestones throughout the entire eastern portion of the quadrangle.

Quaternary

Quaternary surficial deposits within the quadrangle are dominated by loess and alluvium, with lesser amounts of Illinoian glacial till, terrace and fan deposits, and windblown sand. The oldest Quaternary unit in the quadrangle is glacial till of the Glasford Formation from the Illinois episode of glaciation. The Glasford diamicton overlies the bedrock in Greene and Jersey Counties, but Calhoun County is unglaciated. The Glasford Formation was not mapped in the



Figure 4 (left) Photomicrograph of the Hamburg Oolite Bed, which is exposed in Poor Farm Hollow and at the mouths of Godar and DeGerlia Hollows (MS notes 2, 4, and 5). Note the carbonate-coated sand grains. Oolites in the Hamburg Oolite Bed lack concentric calcite rims, which suggests that the oolites are poorly developed.

Figure 5 (below) Carbon content (%C) in the Hannibal Shale from the Juhl #1 core hole in the northern part of the quadrangle.





Figure 6 Angular brecciated chert from the Montrose Chert Member at the base of the Keokuk Limestone in Haushalter Hollow (MS note 222). January 27, 2015.

quadrangle except in two places near Spankey Hill where its presence was indicated by the soils map (Soil Survey Staff, Greene County) and it obscured identification of the bedrock formation. The lacustrine deposits of the Wisconsin episode Equality Formation overlie the Glasford Formation and form broad terraces in small areas of Lincoln Valley, Macoupin Creek, Godar Hollow, and DeGerlia Hollow. The Parkland Sand is a windblown sand deposited near Sand Branch Creek during the late Wisconsinan to early Holocene (David Grimley, personal communication, August 10, 2015) that probably formed from westerly winds transporting outwash sands to the eastern edge of the Illinois River floodplain. The Cahokia Formation includes three facies: 1) an alluvial facies in the Illinois River floodplain and in major tributary valleys, 2) an alluvial fan facies composed dominantly of remobilized loess, and 3) a terrace facies on the flanks of stream tributaries, which can overlie older Wisconsinan terrace deposits. These units were mapped where they significantly obscured the bedrock formation beneath. Windblown loess of the Peoria and Roxana Formations blankets nearly the entire quadrangle, and mapping it would have been counterproductive in producing a bedrock map, so it was not shown on the geologic map or cross section. Where it is not eroded, the total loess thickness in the quadrangle ranges from 12 to 25 feet (Fehrenbacher et al. 1986).

Structure

Hardin Syncline

The Hardin Syncline is a northwest-trending doubly plunging syncline that disrupts the bedrock in and around the town of Hardin (see cross section on map sheet 2). On the west side of South County Road in Hardin, the lower part of the Burlington Limestone was exposed at two localities. Tilted Chouteau limestone dips 10° SSW at the intersection of Franklin Street and South County Road. Tilted Burlington Limestone dips 15° SSW on the south side of the abandoned Calhoun News-Herald Building. South of Hardin at the intersection of Lincoln Valley Road and Illinois River Road, light gray Silurian strata are exposed at road level, and north of Hardin in Poor Farm Hollow, the Upper Devonian Louisiana Limestone is exposed at road level, so the structural relief on the Hardin Syncline is about 200 feet. The average dip on the flanks of the syncline is 5° on the southwest limb and 9° on the northeast limb. Local faulting occurs along the hinge line of the fold in ravines west of Hardin, and closely spaced joints in the south-facing bluff north of Hardin (Fig. 7) suggest nearby faulting.

The major movement on the Hardin Syncline was probably coincident with the major movement of the Cap au Grès faulted flexure, which occurred after the deposition of the Mississippian St. Louis Limestone and before the Pennsylvanian (Rubey 1952). However, Rubey (1952) also recognized that minor movements on the Cap au Grès occurred earlier in the Paleozoic. These movements apparently affected the thicknesses of many of the units between and including the Silurian Bowling Green Limestone and Mississippian Hannibal Shale near 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 120 feet thick and the Hannibal is 80 feet thick in the Juhl #1 borehole. 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. Deep-seated basement faults underlie many structures within the Illinois Basin and along the edge of the Ozark Uplift (Nelson and Lumm 1985, Nelson 1995).

Economic Resources

Limestone

The only active quarry in the quadrangle is the Calhoun Quarry in Jersey County in Secs. 8 and 9, T. 8 N., R. 13 W. This quarry is a surface operation that mines out the high calcium limestone in the lower part of the Burlington Limestone. The Chouteau Limestone is also exposed there, but its quality is too poor for commercial use. There are a few other abandoned quarries, which are marked on the map.

Oil

Four oil test holes were drilled in the quadrangle, and none 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. Carbon content (%C) from potential source horizons in the Grassy Creek Shale, Saverton Shale, and Hannibal Shale (New Albany Group) from the Juhl #1 core hole were analyzed during the study (Figs. 1, 2, and 5). The highest values of 2.05%C were identified in the Nutwood Shale Member of the Hannibal Shale, whereas the Grassy Creek Shale contained a maximum of 1.55%C, and the Saverton Shale contained a maximum of 0.27%C.

Groundwater

Surficial deposits are the primary groundwater source in Calhoun, Greene, and Jersey counties, and wells producing water from bedrock units are much less common. The Illinois River Valley contains sandy alluvial deposits ranging from about 50 to 180 feet thick that are suitable for high-capacity wells (Woller 1975). The Macoupin Creek bedrock valley contains sand and gravel, an excellent source of groundwater (Woller et al. 1990). The Burlington and Keokuk Limestones, as well as the Silurian and Devonian aquifers provide potential for small to moderate-sized groundwater supplies, but the deeper horizons, including the Ordovician St. Peter Sandstone, contain poor quality water (Woller et al. 1990).

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Figure 7 Closely spaced joints suggest nearby faulting related to the Hardin Syncline in the south-facing bluff on the north side of Hardin (MS note 107). December 13, 2014.

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